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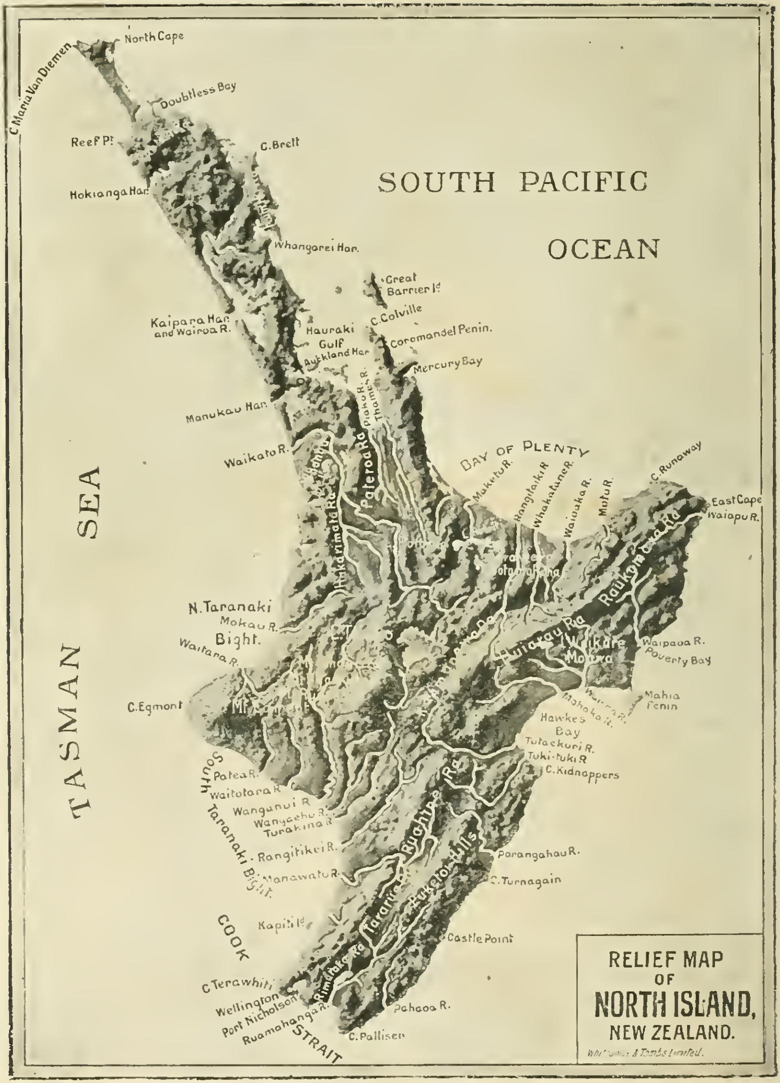

RELIEF MAP OF NORTH ISLAND, NEW ZEALAND.


RELIEF MAP
OF
SOUTH ISLAND,
NEW ZEALAND.
TASMAN SEA
SOUTH PACIFIC OCEAN
WESTLAND BIGHT
CANTERBURY BIGHT
FOVEAUX STRAIT
STEWART ISLAND
C. Farewell
Golden Bay
Takaka R.
Stephen Id
Tasman Bay
Motueka R.
Pelarus Sd
Qn Charlotte Sound
Karamea R.
Karamea Bight
Buller R.
C. Foulwind
Wairau R.
Blenheim
Awotere R.
C. Campbell
Clarence R.
Kaikouras
Grey R.
R. Taramakau
Hokitika
Waiau-uha R.
Hurunui R.
Pegasus Bay
Waimakariri R.
Lyttelton Har.
Banks Peninsula
Akaroa Har.
L. Ellesmere and Selwyn R.
Rakaia R.
Canterbury Plains
Ashburton R.
Rangitata R.
Opihi R.
Haast R.
Arawhata R.
Cascade Pt
Big Bay
Milford Sound
George Sound
L. Tekapo
L. Pukaki
L. Ohau
L. Wanaka
L. Hawea
Waitaki R.
Shag R.
Otago Har
C. Saunders
Dunedin
Taieri R.
Tokomairiro R.
Clutha R.
Mataura R.
Invercargill
Dusky Sd
C. Providence
Preservation Inlet
Puysegur Point
Waiau R.
Aparima R.
Oreti R.
South C.

The Geography of New Zealand.

HISTORICAL, PHYSICAL, POLITICAL, AND COMMERCIAL

BY

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PREFACE.

Dr. H. R. Mill, in a paper on the scope of Geography has lately given the following definition :—" Geography is the science that deals with the forms of relief of the earth's surface and with the influence that these forms exercise on the action of all other phenomena." The origin and development of the forms of relief must first be considered, and the influence that they have exerted upon the distribution of the areas of land and water, thus embracing the branch often known as physical geography. Next follows a consideration of their effects upon the circulation of the atmosphere and upon the radiation of solar energy that reaches them. All of this is embraced in the consideration of climate. The distribution and nature of plants and animals is evidently dependent, in the main, upon the nature and distribution of these forms of relief and on the climate that they influence. Also, in conjunction with the distribution of mineral deposits, they determine the areas of human occupation and the nature of the industries that are maintained. Finally, the consideration of the industries leads naturally to an account of the political institutions by which the population is governed, and the commercial arrangements by which the products of the industries can be brought to a market.

It was with the idea of describing New Zealand, according to the spirit of the new Geography, that this book was written.

Professor Gregory, the editor of the series of State Geographies, has contributed the Introduction and a chapter on the Geysers. The views stated by him are not in all cases fully upheld in the body of the work. For this the author is wholly responsible. The sudden removal of Professor Gregory to Scotland entirely prevented the possibility of transmitting the proof sheets for his perusal. Thus some matter has crept into the physical portion of the book that certainly would not have received his approval. This is most prominent in regard to the influence of the erosion of ice on the land forms of New Zealand. Conclusions are given that are based on the author's own observations combined with those of American observers and of Professor Penck, in Germany.

Professor Gregory kindly cabled permission to omit from his introduction all those portions that conflicted with the description in the later pages. Some advantage was taken of this generous permission, and the discrepancies have thus been lessened. It was, however, evident that very serious omissions would have been

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necessary to secure cemplete agreement, and this might have implied that Professor Gregory approved of those portions that differed from his statements. In order to avoid such a partial misrepresentation, it was decided to include nearly all his Introduction, especially as it was felt that an article from such an able and experienced geographer ought not to be lost to New Zealand geographical science.

In some matters it is possible that too sweeping and unsupported statements are made. The origin and development of the drainage basins of Otago in particular are given more fully than in any previous description of them, and objection may possibly be taken to the account here given. The arrangements and nature of the land forms in that region are so peculiar that some explanation was necessary, and the one given is that suggested by a personal study of the district.

Much of the information in the book has been gathered from previous publications. The historical section is chiefly based on Brett's *Early History of New Zealand.* The account of the climate is based on Captain Edwin's papers in the *Transactions* of the New Zealand Institute, and upon the returns of the Meteorological Department. The *Official Year-Book* has provided most of the data for the commercial and political divisions. The matter composing the chapter on the Fauna and Flora is in part derived from the excellent book, *The Animals of New Zealand* by Hutton and Drummond, and from the Introduction to the *Index Faunæ Novæ-Zealandiæ* by Captain Hutton, F.R.S.

Illustrations have been derived from various sources. A few of the blocks have been used before in Messrs. Whitcombe and Tombs's publications, others have been made from photographs, in the possession of that firm. Several are from my own photographs, a few from the photographs kindly given me by Mr. E. E. Collier, and some from sketches. The maps are copies of those issued by the Government Survey Department. The semi-relief map was drawn by myself from personal knowledge of the country, combined with details given on the survey maps. Those of Lakes Taupo and Wakatipu are from Lucas's paper in the *Geographical Journal.* The rainfall map is based on meteorological returns. The data for the map of cotidal lines and currents were obtained from the *New Zealand Pilot.*

Whatever value the book may have, will, I feel, be in no small measure due to the chapters on Earthquakes and on The Maoris written by Messrs. G. Hogben, M.A., and A. Hamilton respectively, and to the articles written by Professor Gregory mentioned above.

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INTRODUCTION.

THE GEOGRAPHICAL PLAN OF NEW ZEALAND.

(J. W. GREGORY, D.Sc., F.R.S.)

The fortunate inhabitants of New Zealand should be geographers by instinct; for New Zealand consists of a collection of geographical models, from which true geographical ideas should be unconsciously absorbed. There is no other land area of equal size which is so varied and so complete. It is unique from the combination of the variety of its land forms, the clearness of their development, and the simplicity of their arrangement.

New Zealand—its structure continental. New Zealand in the first place has an interesting combination of continental and oceanic characters. It is continental in structure. The rocks are of the same kind as those of which the great continents are built. New Zealand has an exceptionally full series of representatives of such rocks. It has as complete a rock sequence as the continent of Australia, which is more than thirty times as large. Vast areas of Australia, owing to its stability and geographical

conservatism, consist of the same rock; and the continent is therefore somewhat monotonous in structure and history. New Zealand, on the other hand, has been alternately rising and falling, under the slow heaving of the earth. The rocks formed along the shores at each period of sinking, have been covered by later rocks; and the thick rock masses,

The Kakapo.

having been raised again above sea level, have been cut through by deep river valleys, and their layers thus fully exposed to our inspection.

Its flora and fauna oceanic and archaic. Though the islands of New Zealand are continental in composition, the animals and plants have the interest that comes from slow natural development, unspoiled by intermingling with alien elements. The animals found in New Zealand compensate for their small numbers by their extreme interest; for they belong

to races that date from a long past age; such for example are the Hatteria (Tuatara), the quaint lizard with a third though rudimentary eye in the middle of the head; the now extinct Moas, the giant birds that could not fly; and quaint birds such as the Kakapo, a nocturnal parrot. The absence of higher animals, however, is in nowise due to the unsuitability of the land; for since their introduction by man, they have multiplied amazingly, and spread throughout the land; thus the Weasel has increased so fast in Westland, that it threatens to exterminate many of the native birds.

So complete has been the geographical isolation of New Zealand that it was uninhabited by man, until some seven centuries ago, when the Maoris reached the North Island after an adventurous voyage in their great war canoes, from distant homes in the Pacific. The land was, however, eminently suited for occupation by man, for it yielded abundant food, with its many fat sluggish birds, the shoals of fish in its rivers, its rich soil and plentiful rain, its wealth of easily worked, useful timber, and its great variety of useful, fibre-producing plants. It is blessed, moreover, with the bracing climate of the temperate regions, and the luxuriant vegetation and fertility of the tropics.

It is geographically young. New Zealand consists of old rocks, and, thanks to its isolation, it is occupied by archaic animals and plants, but the frequent earthquakes at Wellington and in a minor degree elsewhere, show that great earth movements are still in progress; the geysers of Lake Taupo and Rotorua, and the steaming volcanoes of the same area, are

signs that the foundations of the North Island are unstable and in a state of change.

The very existence of lakes and waterfalls, which

Sutherland Falls, 1904 feet.

are among the scenic glories of New Zealand, is evidence of change of conditions; for all waterfalls are slowly destroying themselves by wearing away the barriers over which they leap, and lakes are

being destroyed, by being filled by debris or drained by the cutting down of their outlets. New Zealand is still immature, despite the fact that the geographical agents are working with unusual activity, and the country is being rapidly worn down by powerful forces. The perpetual snow-fields of the Southern Alps feed great glaciers, which flow down the mountain valleys, sweeping away the cover of debris, that usually protects the underlying rocks from decay. The heavy rainfall of the West Coast feeds the torrents that dash down the western slopes of the mountains and rush in impetuous floods across the coastal flats; and it maintains the larger rivers that flow across the eastern plains to the Pacific, over mile-wide beds of shingle.

Variety and freshness of its land-forms. The continued action of the forces that gave New Zealand its present land-forms keeps their characters clear and fresh; for, although they are being continually worn away, they are being as steadily renewed. It is the geographical immaturity of New Zealand that renders the contrast between its varied land-forms so remarkably distinct. Each area shows its essential geographical characters with the clearness of a diagram. The highlands of Otago occupy the site of an ancient mountain range, which was planed down to a low lying plain, some of the old surface of which can still be recognised at Pukerau, near Gore; but the plain was lifted up to a plateau, and the rivers of the district, the Mataura and the Clutha, have gouged their valleys out of it. Thus the old plateau has been carved into an area of undulating highlands, intersected by deep valleys, with terraced

banks, and with here and there a tract of fertile plain, which represents some filled lake basin.

A striking contrast to this newly dissected plateau is offered by the Southern Alps, the great mountain chain of the South Island. Their rugged lofty peaks, rising in the case of Mt. Cook to the height of 12,349 feet above sea level. their narrow precipitous ridges, their deep mountain gorges, their broad snowfields and great glaciers, are all symptoms of a recent elevation. The valleys of the Fiord-land of the south-western corner of New Zealand offers as striking evidence of immaturity as the ridges of the Southern Alps; for the fiords are bounded by steep cliffs, their course is straight and their tributaries join them with sharp corners, not yet rounded off by weather. Further north is the narrow coastal plain of Westland, lying between the foot of the mountains, and the long, low coast line of the Southern Ocean. The mountain valleys, which open on to Westland, and the hills that face it, are almost impenetrable owing to the denseness of the vegetation maintained by the heavy rainfall; for the winds that blow in from the sea are heavily laden with moisture, which they drop when they are chilled by contact with the cold snow-capped mountains. But the eastern slopes on the Alps have a much lighter rainfall and in places they actually show an arid, desert landscape. Thus *e.g.* around Mt. Torlesse, the valleys are choked by waste material, which the rivers have not sufficient power to remove; the hill sides are streaked by white lines of debris, which, in a wetter region, would be washed down on to the floor of the valleys; and the lower slopes of the hills

are buried beneath talus, or sheets of rough, rock fragments.

The Canterbury Plains represent yet another type of scenery; but as they, also, are of recent age, they still show clear evidence of their origin. They begin as a series of broad river-beds among the Alpine foothills; on leaving the hills they widen out to fan-shaped deltas, which are united at their edges,

The Gorge of the Wanganui.

into one vast, wide-flung plain. This plain has a steady eastward slope, down which the rivers rush in uncontrolled floods, through ever changing courses, until they discharge into the Pacific Ocean.

At Nelson on the floor of a wide basin between the mountain ranges to the east and west, is a delta of another type. This delta now occurs as a great fan-shaped hill, which shows clear evidence of its mode

of formation, although the river that made it has been long since destroyed by the capture of the water that once flowed into Tasman Bay by the Buller River, which now discharges it to the Southern Ocean.

The North Island has its own well marked types of scenery. The deep gorge cut by the Wanganui through the soft marls of its basin; the bare moors of the Thames Goldfields; the Hauraki Gulf formed by the drowning of a river valley, which has sunk below sea-level; and most famous of all, the volcanic zone of Taupo, with its broad lakes, its snow capped steaming volcanoes, its extinct craters, its sulphur springs, geysers, mud volcanoes and hot springs, and its sheets of pumice and volcanic ashes that litter the broad plains of the volcanic belt.

The scenery of New Zealand is world famous for its beauty, while its variety is even greater than its reputation. The instructive clearness of the contrasts between its various geographical land-forms is due to its immaturity. Beaches that are still fresh, mark the recent elevation of the coast lands. For though

> "Nature softening and concealing
> Is ready with a hand of healing,"

she has not yet had time to efface the tool marks of the processes to which the geographical features of New Zealand are due.

Former greater extent. The present geographical plan of New Zealand shows that some comparatively recent changes have greatly reduced its area. On all sides are signs that the present archipelago is the remnant of a once more extensive land. The country

must once have extended westward, far beyond the present coast of Westland. The rivers of Westland contain many nuggets and grains of gold; and some of the miners say that this gold cannot have been derived from rocks to the east, for the gold becomes coarser as the rivers are followed downwards towards their mouths; whereas, if the gold had been brought down by the existing rivers from the rocks of the present hills, it should be coarsest to the east. Hence it may have been a rich treasure-land that has foundered beneath the Western Sea. The evidence for this view, however, is not convincing. For example, stand on the crest of the ridge, where the road from the western coast crosses the mountains towards Nelson, and look around you, with your eyes half closed, so as to blur the nearer and the minor details in the view; the country then appears as a broad plain, above which, far to the South, rises the snow-clad summits of the Spencer Mountains. and the nearer spurs of the Marine Range. The neighbouring ridges have a general slope down to the north; and the general impression given by the view is that the country was once a level plain sloping gradually downward, to the lowlands of Nelson; but this plain has been destroyed by the rivers cutting their valleys deeply into it, so that the former plateau has been carved into a complex series of hills and valleys. If we look at the adjacent rocks, this impression is confirmed. The lower part of the valley of the Hope River, near its junction with the Buller Valley, is cut in hard. old rocks. But the high ridge that divides the Buller from the rivers that drain northward into Cook Strait is

capped by a thick mass of soft clays and gravel. These deposits were left by the river that once rose on the mountains to the south and south-west and crossed the present divide, where these remnants of its bed witness to its former existence and mark its course.

The Mountain System.

Both the political and physical geography of New Zealand are largely dependent upon the arrangement of its mountains. New Zealand includes four distinct different kinds of mountains, which date from three distinct eras. The most conspicuous mountain system is composed of two parallel mountain chains trending from south-west to north-east; each of these chains consists of a series of mountain ranges, which owe their present elevation to earth movements that folded the rocks along axes running from south-west to north-east, or uplifted blocks of rocks of which the faces trend in the same direction. The most important member of this mountain system is the chain of the Southern Alps, which has been the best known element in New Zealand geography, since its snow-covered peaks were discovered and named by Captain Cook.

1. **The Southern Alps.**—The Southern Alps consist of a foundation of the most ancient rocks in New Zealand, capped by overlying sheets of slates and sandstones, which, though young in comparison with the rocks beneath them, are still of venerable antiquity. The mountains of this chain are separated from the western coast, by the low narrow coastal plain of Westland; but, further south, they

appear to reach the coast and present a bold front to the Southern Ocean. The Alpine Chain dominates the whole geography of the South Island. It is the divide which separates the rivers that flow across the eastern plains to the Pacific Ocean from those which rush impetuously westward into the Southern Ocean. It is the great barrier between east and west, and thus keeps the province of Westland in its comparative isolation.

This great mountain chain ends abruptly to the north at Cook Strait, and one naturally looks across the Straits to find its continuation in the North Island. There, however, we find no sign of it. In the North Island the highest mountains are isolated volcanic cones; there are long, continuous ridges, rising here and there into lofty alpine peaks; and the old rocks, that form the foundation of the alpine chain, have no representatives on the surface of the North Island. The extension of the line of the Southern Alps is occupied by a great sheet of Cainozoic marine rocks, occupying the basin of the Wanganui; still further along the same line is the volcanic basin of Taupo and Rotorua. The Alpine Chain must once have extended to the north, forming the backbone of the southern half of the North Island. But the whole Alpine belt has disappeared from the North Island.

There is therefore at present a striking lack of symmetry between the North and the South Island; for the North Island has no representative of the Alps, and the South Island has nothing comparable to the volcanic region of the North Island.

2. The eastern mountain chain. The former close connection of the two main Islands is however, shown by a second mountain chain. This chain is represented in the South Island by the Kaikoura Ranges, which run parallel to the Alpine Chain, in the north-eastern corner of the South Island. They cross the province of Marlborough, where they

The Kaikouras.

consist of two parallel ranges—the Inland and the Seaward Kaikoura Ranges. They both end on the shore of Cook Strait between Blenheim and Cape Campbell; and they are continued in the North Island by mountain ranges, which are built with the same structure, run with the same course, and are composed of similar materials. These ranges form the backbone of the Wellington promontory and run along the boundary of the province of Hawke's Bay

into eastern Auckland, where they end on the coast between Cape Runaway and East Cape. These ranges are known as the Tararua, Ruahine, and Raukumara Ranges.

The eastern mountain chain of New Zealand is therefore found in both Islands. It is abruptly cut off to the south by the depression occupied by the Canterbury Plains; and to the north, by the sudden bend in the eastern coast, which, at East Cape, abruptly turns north-westward at right angles to its former course along the eastern shore of both the North and South Islands.

3. **The volcanic mountains.** The third class of mountains in New Zealand are volcanic in origin. They may be arranged in two groups, those which occur on projections from the present coast line, and those in the volcanic area of the North Island.

The volcanic mountains occurring as projections from the coast line have three chief representatives. The first is Mount Egmont, the snow-capped, shapely cone, which rises on the northern shore of Cook Strait, at its western end. Mount Egmont has a well-preserved crater, though the volcano is extinct. Two other members of this group are older, and consist of the weathered, worn-down stumps of older volcanoes. They both occur on the eastern coast of the South Island, and form the Banks and Dunedin Peninsulas.

The great volcanic area of the North Island occupies the sunken area from the south of Lake Taupo to the Bay of Plenty. Here occur the chain of the great volcanic cones of Ruapehu, Ngauruhoe,

Mt, Egmont, Taranaki, 8260 feet.

and Tongariro; the extinct volcanoes Tauhara, Mount Edgecumbe, Rainbow Mountain; and the still active volcano of White Island. Here also is the old volcanic mass of Tarawera, the renewed activity of which, by a terrific explosion on the night of the 10th June, 1886, devastated the adjacent area, and blew up the Pink and White Terraces, the most attractive of the many attractions in New Zealand, leaving a vast crater 500 feet deep beneath their site.

Difficulty of internal communication and its effects. The recent date at which so many of the leading geographical features were stamped upon New Zealand will have a powerful influence on the political and social development of the State. Geographical barriers are more effective when they are young than when they are old; for, when the hills are worn down by wind, rain, and streams, roads are easily made across them; and, when the rivers have had time to cut down their beds, they wear away all the cataracts and waterfalls, and become aids, instead of obstacles, to transport; rocky barren regions are covered by a layer of soil, so that agricultural settlement can be more continuous and widespread. And as the rivers wear away their beds near their mouths, estuaries and harbours are formed along the coasts.

Hence it is only natural in a country geographically so young as New Zealand, that there is especial difficulty in inland transport; and that the settlements have grown up around a series of centres, which are comparatively isolated and self-contained. Thus Dunedin is the commercial centre of the

southern half of the South Island, as Christchurch is of the rich Canterbury Plains; Nelson lies secluded in the basin leading inland from Tasman Bay; Auckland, the business centre of the northern end of New Zealand, owes its importance to its position, easy of access from the land beside the many branches of the Hauraki Gulf. Wellington owes its rank as the administrative capital to its central position; but it is never likely to acquire the political, commercial, or intellectual predominance of the capital cities of the more populous Australian States, where, for example, the city of Melbourne draws to itself nearly one-half of the population, and administers nearly all the business of Victoria. And even when the utilisation of the infinite water-power that now runs to waste down the Alpine rivers shall have made New Zealand the centre of the electro-chemical industries of the Southern Hemisphere, the geographical factors will still tend to its development as a number of local communities, more independent and diverse than in any other of the States of Australasia.

Part I.—HISTORICAL.

Chapter I.—SITUATION AND BOUNDARIES.

The 34th parallel of south latitude passes about 20 miles to the north of the North Cape of New Zealand, and the 48th parallel passes about 30 miles to the south of Stewart Island.

The main land area of the colony of New Zealand lies between these two parallels of latitude. The trend of the land is from south-west to north-east from the southern extremity of Stewart Island until 38° south latitude is reached. The northern portion of the North Island trends considerably to the west of north. The Tasman Sea bounds the land on the west, and elsewhere it is bounded by the South Pacific Ocean.

The land is nowhere more than 280 miles in width, and, except at Auckland, and to the north of that town, is nowhere less than 60 miles broad. This main land mass of New Zealand lies between 166° and 179° east longitude.

The actual boundaries, as defined by proclamation, extend far more widely.

The New Zealand region extends from 33° to 53° south latitude, and from 162° east longitude to 173° west longitude.

The **Kermadec** region extends from 29° to 32° south latitude and from 177° to 180° east longitude.

The Cook Islands region commences 8° of latitude south of the equator, and between the longitude 156° and 167° reaches to latitude 17° south. There it widens to the meridian of 170° and extends to 23° south.

The important islands and groups enclosed by these boundaries are—

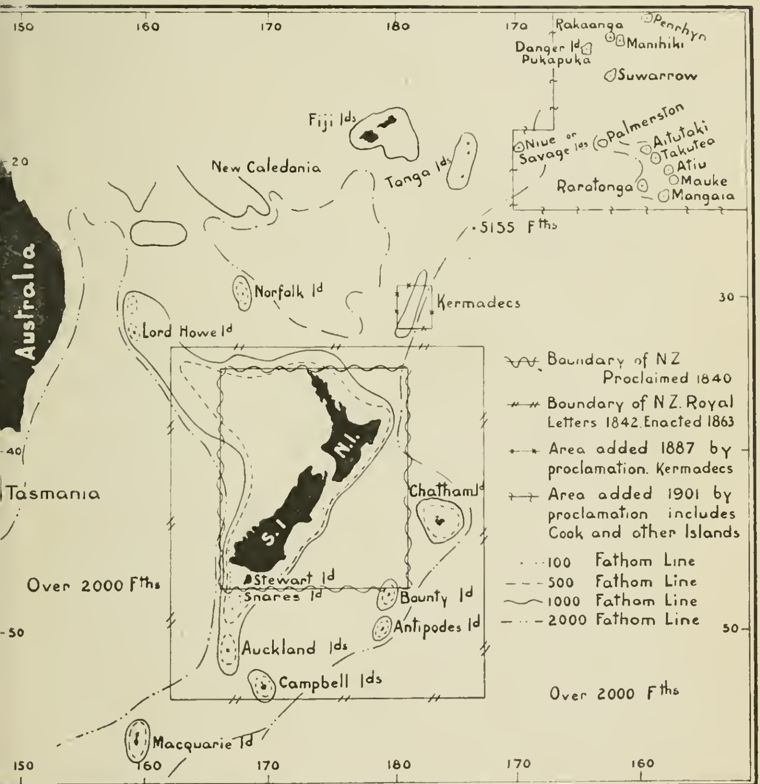
1. The islands of New Zealand proper. (*a*) The North Island; (*b*) the Middle Island, generally called South Island: and (*c*) Stewart Island.
2. Auckland Islands.
3. Campbell Islands.
4. The Antipodes.
5. The Bounty Islands.
6. Chatham Islands.
7. Kermadec Islands.
8. Cook Islands.

The whole land area comprised by these groups is 104,751 square miles, an area larger than that of Tasmania (26,215 square miles), and Victoria (87,884 square miles), but smaller than that of any of the other Australian States, the smallest of which is New South Wales, 310,700 square miles.

The North Island of New Zealand has an area of 44,468 square miles. Its length is 515 and its breadth 280 miles. The Australian coast between the same latitudes as the North Island extends from Sydney to Launceston. The corresponding latitude in the Northern Hemisphere includes the distance from Madeira to Oporto.

The South Island has an area of 58,525 square miles. Its length is 525 miles, and breadth at the

widest part 180 miles. In latitude it extends from the north of Tasmania to 400 miles to the south of the island, and in Europe from Oporto to Nantes.



Map showing successive boundaries of the Colony of New Zealand, and depths of the surrounding ocean.

Stewart Island about 30 miles long, is in area 665 square miles. Its southern extremity has not quite so high a latitude as the southernmost extremity of the British Isles.

The Auckland Islands (area 140 square miles) are in almost the same longitude as Stewart Island, but 200 miles further south.

The Campbell Islands are the most southern portion of the colony. Their area is 40 square miles, and their latitude is the same as that of Cambridge in England.

The Antipodes Islands (area 8 square miles) are situated 400 miles to the east of Stewart Island.

The Bounty Islands are 50 miles to the north of the Antipodes. Their area is only 2 square miles.

The Chatham Islands, 536 miles to the east of **Lyttelton** cover 375 square miles.

The Kermadecs lie almost in the same longitude as the Chathams, but are nearly 900 miles further north. Their total area is five square miles.

The Cook and neighbouring islands have a total area of 280 square miles. The most important island, Rarotonga, is 1,638 miles north-east of Auckland. The furthest island of the group is 700 miles distant from Rarotonga.

The **isolation** of New Zealand as a land mass is emphasised by a study of the soundings that have been made in the surrounding ocean. On all sides the bed of the Pacific sinks down to more than 1,000 fathoms below sea level before any large land surface is met with.

There are, however, marked differences in the rate of increase of depth in different directions. The 100 fathom line includes Stewart Island and the Snares, but passes everywhere rather closely to the coast, though generally further away on the west than on the east. The 1,000 fathom line encloses the

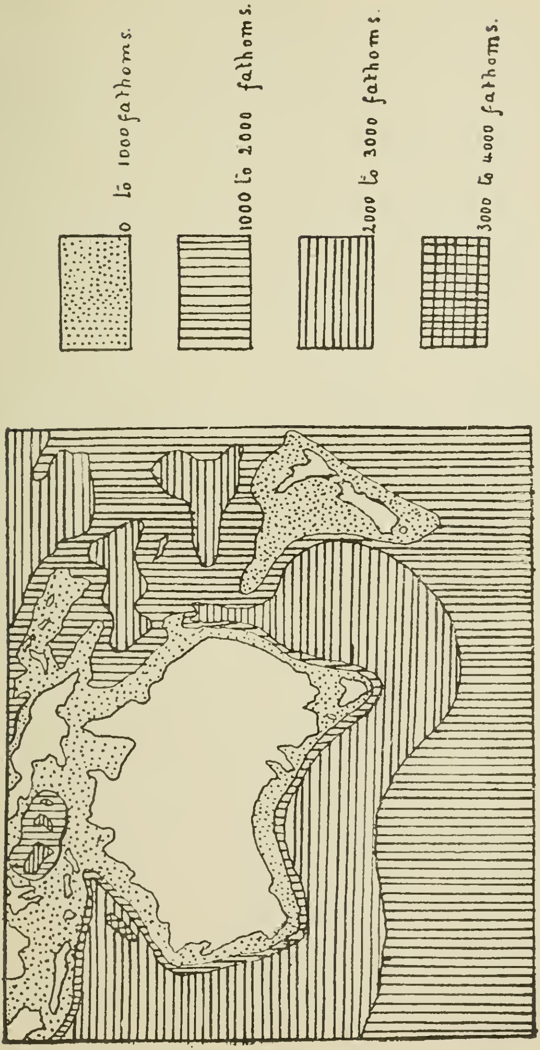
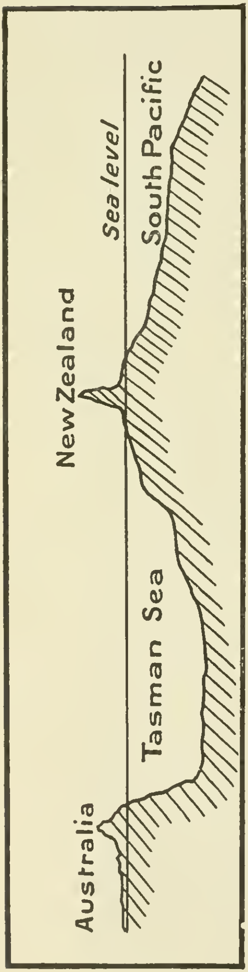


Chart of Ocean Basins around Australasia.



Section across Tasman Sea from Mt. Kosciusco to Mt. Cook.
Horizontal Scale—1 in 45,000,000. Vertical Scale—1 in 540,000.

Auckland Islands but not the Campbells or Chathams. It extends in a long narrow tongue past Lord Howe Island to the north-west, in which direction small strips of deeper water but still less than 2000 fathoms deep separate the narrow tongue from the shallow water extending round the north-east part of the Australian continent. To the north-east a well-defined ridge less than 2000 fathoms deep connects New Zealand with the Kermadecs, Tonga Islands, and Fijis.

Southwards of New Zealand the Antarctic Ocean appears to be comparatively shallow, as no depths greater than 2000 fathoms have been recorded in it.

Between New Zealand and Australia, in the Tasman Sea, a deep area

exists, which does not extend so far north as New Caledonia. To the north-east of New Zealand, close to the east of the Kermadec Islands, there is a deep basin in the Pacific Ocean in which a sounding of 5,155 fathoms was obtained by "H.M.S. Penguin" in 1896. Only one deeper area is known; it lies to the east of Guam.

Chapter II.—DISCOVERY AND EXPLORATION OF NEW ZEALAND.

"A great, high, bold land" was sighted on December 13, 1642, by **Abel Tasman**, then on a voyage of discovery in the South Seas. He called the land "Statenlandt," thinking at first that it might be continuous with a previous discovery, or that it might be a part of the unknown, though suspected, southern continent. Tasman first sighted New Zealand a little to the north of Mount Cook, and the land seen by him was a portion of the Southern Alps. He continued his voyage northward along the coast, and before long entered Cook Strait, which he mistook for a gulf. He came to an anchor in Massacre Bay, now Golden Bay, and was soon visited by the "Indians" in a "prow." They, taking advantage of the opportunity when a boat was rowed from Tasman's consort to his own ship, attacked the rowers and killed three of them.

Tasman no longer tried to establish friendly relations with the "Indians," but sailed further north, first sending some round shot among eleven

Abel Tasman's Map of the New Zealand coastline, with actual coastline for comparison.

(By kind permission of Dr. Hocken, from Trans. N.Z. Inst., Vol. xxviii.)

"prows" that were apparently going to attack him. Sailing up the west coast, he passed Mount Egmont though without seeing it, but sighted Mount Karioi, a much smaller mountain further north, between Kawhia and Raglan, and finally reached the Three Kings, whence he sailed away to the west. He did not land anywhere in the islands he discovered but some of the names of prominent coastal points were given by him, such as Cape Maria van Diemen and the Three Kings.

After Tasman had left its shores, it appears that New Zealand was not again visited until the great navigator, **Captain James Cook**, arrived in 1769 in the *Endeavour* of 370 tons. During his first voyage he spent six months in New Zealand waters.

The land was first sighted in October, at Poverty

Captain Cook.

Bay. Thence Cook sailed south as far as Cape Turnagain, where, turning to the north, he coasted almost completely round the island. He spent some time at the Thames, where he was struck with the majesty of the kahikatea (white pine) trees. Rounding the North Cape he sailed down the West Coast and refitted in Ship Cove in Queen Charlotte Sound. Afterwards he sailed through the straits between the two islands, and established the fact that the large inlet into which Tasman had sailed was no mere arm of the sea, but a strait which has since borne the name Cook Strait. Reaching the East Coast he sailed as far north as Cape Turnagain, then heading south, he sailed right round the South Island passing to the south of Stewart Island, which he imagined to be part of the larger island. He tried to enter Dusky Sound, but was prevented by bad weather and sailed on northwards, and, on reaching the western entrance to Cook Strait, turned away towards Australia. He described the South Island as a mountainous, and to all appearance, a barren country, but the North Island appeared to him to be much more attractive. The Thames district and Bay of Islands he considered the best localities for settlement. The natives he describes as "a strong, raw-boned, well-made, active people." Their warlike propensities made them at first resent the approach of strangers, but, in nearly all cases, Cook's tactful and firm behaviour soon induced friendly relations. Their cannibal habits were evident to him, but he could offer no explanation of the origin of such customs.

In his **second** voyage, undertaken in 1772 in the *Resolution*, 464 tons, he reached Dusky Sound in 1773. Here he refitted and sailed north to Queen Charlotte Sound, where, by previous arrangement, he rejoined his consort, the *Adventure*, from which he had become separated during the voyage from England. In Dusky Sound he found some natives, but none have been seen there since. He left New Zealand in June for the Pacific Islands, but returned in October, and made further voyages along the coast.

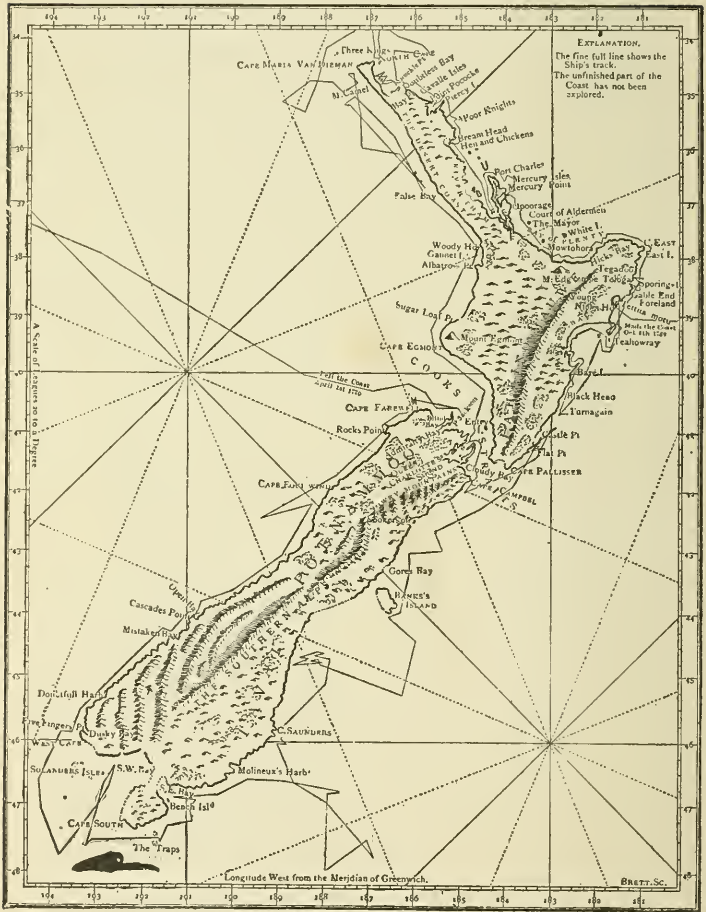
During the same voyage he returned a year later, but called only at Queen Charlotte Sound to make necessary repairs to his ship. Whilst there he found that the *Adventure*, from which he had accidentally parted company when last on the New Zealand coast, had called at the Sound, and it was afterwards found that a boat's crew had been murdered there by the natives. He sailed from New Zealand across the Southern Pacific to South America.

In the **third** voyage Cook visited New Zealand only once, in February, 1776. He again visited Queen Charlotte Sound to repair the damages his ship had suffered, and to refresh his crew.

To Captain Cook we are indebted for the first accurate knowledge of the New Zealand Coast. The extent to which the coast was surveyed by him is a tribute to the fearless and thorough nature of his navigation. It is probable that a less tactful commander would have been far less successful in this matter, for success to some extent depended upon the establishment of friendly relations with the natives. They were a warlike aggressive people, and

COOK'S CHART OF NEW ZEALAND.

Shewing the results of Lieut. Cook's observations during the voyage of the Endeavour.



Published 1st January, 1772.

the difficulties of dealing with them is evidenced by the failures of other voyages and the loss of many other ships on the New Zealand coast. Cook, by his intrepid action yet forbearing and generous behaviour, succeeded where many other navigators as good as he might well have failed.

We owe a number of our coast names to Captain Cook, and his own name has been given to the highly important geographical feature of New Zealand, Cook Strait, and more recently to the highest mountain of the country, to a river in Westland, to a county, and we have even a Cook's Cove.

The names he gave were at times suggested by appearances presented by the land, as Dusky Bay and Saddle Hill. In other cases the ease or difficulty of procuring provisions suggested such names as Poverty Bay and Bay of Plenty, though now the former is highly inapt. Incidents of his voyage prompted such names as Cape Kidnappers, Cape Turnagain, and Ship Cove. Officers of the ship sometimes had their names perpetuated, as Solander Island and Hicks Bay. The names of prominent statesmen were utilised, as Mount Egmont and Cape Rodney.

Cook laid down a firm and substantial foundation of the geographical knowledge of New Zealand. His surveys were remarkably accurate, and in many portions remained the standard until the visit of the *Acheron*, 1853. His explorations were however confined to the coast, and it was long before any knowledge of the interior of the country was acquired.

New Zealand was visited by two French navigators, Surville and Marion du Fresne, soon after Cook's visit. The former did little more than touch the north, and the latter was murdered with a boat's crew by the Maoris in the Bay of Islands in 1773. For almost fifty years after Captain Cook's last voyage, no systematic attempt was made at settlement in New Zealand. Whalers and timber vessels frequented various harbours in the north of Auckland, especially the Bay of Islands. But whales were also plentiful in the south, and ships were fitted out to catch them. The captain of one of these was the navigator who discovered Foveaux Strait in 1806, and his name has been given to Stewart Island. Previously it had always been supposed that this was an integral part of the South Island.

The Chatham Islands were discovered by Lieutenant Broughton, in 1790, when on a voyage from Dusky Bay to Otaheite.

The various groups of Southern Islands were discovered very early in the nineteenth century.

The Antipodes Group, one of the smallest, were sighted in 1800 by Captain Pendleton.

In 1806, the Auckland Islands were discovered by Captain Bristow in command of a whaler.

The Campbell Islands remained unknown until 1810, when the brig *Perseverance*, in command of Captain Hazelburgh, discovered them, and named them after the owner of his ship.

Some of the islands of the Kermadec Group were sighted in 1793 by Captain Severne, of the *Lady*

Penrhyn; but Sunday Island, the most important of the group, was unknown until the visit of Captain D'Entrecasteaux, of *L'Esperance*, in 1793.

The most recently annexed of the outlying islands of New Zealand—the Cook Islands—were the earliest discovered. In 1772, the great navigator, whose name they now bear, sighted Mangaia, Atiu, and Aitutaki, three of the most important islands of the group.

Chapter III.—COLONISATION

The whalers added no solid information as to the geography of the islands. For the most part they lived when ashore on amicable terms with the Maoris, and the members of the shore stations intermarried with them. From time to time visiting vessels were captured by the Maoris in out of the way parts and their crews were murdered. In all these cases it appears that the resentment of the natives was aroused by some infringement of the Maori law and such infringement was punishable by death. Of such disasters the capture and destruction of *H.M.S. Boyd* at Whangaroa in 1804 is the best known.

An attempt was made to form a permanent settlement by **Captain Herd,** who went to the Hauraki Gulf in 1825. He was under the impression that he had bought the title to a large area of land there from the native owners. When he arrived, the district was being raided by one of the Northern chiefs, Hongi, and the desolation and danger appeared so great that all attempts to form a settlement were given up by him.

The **visits of whaling ships** to the Bay of Islands became more and more frequent, and finally a settlement of a permanent character was the result. New Zealand had, however, still no resident official who could be regarded as responsible for order or government. The whalers had a rough and summary law for themselves and treated the natives without any assertion of dominance.

This irregular settlement had become so important in 1833 that the New South Wales government, which then had nominal jurisdiction over New Zealand, sent **Mr. Busby** as a permanent official British Resident, who was to be responsible for law and order.

The Resident, who was stationed in the Bay of Islands, was, however, not backed by any force that could compel obedience, and, situated as he was 1500 miles from his superior, to whom he had to apply in emergencies—with uncertain communication—experience soon showed that little was gained by his appointment.

Some time previously—as early as Christmas Day 1814—missionary enterprise had commenced. **Samuel Marsden**, chaplain to the N.S.W. Government, interested in the occasional Maori visitors to Sydney, journeyed to New Zealand to make arrangements for regular ministrations to them. He travelled over many parts of the interior hitherto unvisited by white people, and finally left two missionaries behind him. These two men formed a nucleus of a band who, amid trials and persecutions, and at great personal risk, planted

missionary stations throughout the Northern part of the North Island. In no small measure did these early missionaries pave the way for subsequent negotiations with the natives and render them amenable to progress and advance.

An additional British Resident, named Macdonell, was appointed for Hokianga in 1835. His efforts to enforce order and represent the authority of the British Government appear to have been no more successful than those of Mr. Busby. In 1837 the colonists sent a petition "to the King's most excellent Majesty" asking for sufficient protection. The petitioners stated that Baron de Thierry threatened to usurp power over New Zealand. They mentioned the disturbance to which the excesses of visiting crews gave rise and enlarged upon the salubrity of the climate. Baron de Thierry professed to have bought the sovereignty over New Zealand from the noted chief Hongi when he visited England. He was unable, however, to establish his claims when he landed in the country in 1837.

Rev. Samuel Marsden.

In London a New Zealand Association, consisting of many eminent statesmen and others, was formed in 1837 for the purpose of colonising these islands. It was, however, opposed by the Government and achieved no noteworthy results.

Moral and legal irregularities were committed so frequently at the whalers' settlement at Kororareka that, in 1838, the colonists united to form a Kororareka Association to protect households and properties. The most serious punishment meted out was that of tarring and feathering offenders.

An event of great import to New Zealand occurred in 1839, when the **New Zealand Company** was formed; its members consisted partly of the old shareholders in Captain Herd's project, partly of the old New Zealand Association. Again the policy of colonisation in such distant regions was not favoured by the English Government; but the Company decided to carry out all details of settlement on their own responsibility. The surveying vessel *Tory* was despatched from London in May, 1839, and arrived at Port Nicholson in September. Colonel Wakefield, the representative of the Company, at once negotiated with the natives of the district for the title to the surrounding land, and was able to report from Waikanae on October 23rd that he had bought all the land extending on the east coast from 41° to 43° of S. latitude, and on the west coast from 39° to 43°. Further north, similar but smaller land purchases were made by the New Zealand Land Company and the Manukau Land Company.

In the meantime—on the 15th June, 1839, the boundaries of New South Wales had been extended

to include New Zealand and, on the 13th July, **Captain Hobson** was appointed "Lieutenant-Governor of all territory which is or may be acquired by His Majesty in New Zealand." Captain Hobson was instructed to establish a government with the free consent of the natives. He at once proclaimed that no land was hereafter to be bought from natives except by the Crown, and no titles except those of the Crown Grant were to be recognised.

Treaty of Waitangi.—Captain Hobson arrived in the colony at Kororareka in the Bay of Islands on January 29th, 1840. On February 5th a meeting of natives was summoned by him at Waitangi and signatures were obtained to the treaty by which all rights and powers of sovereignty were ceded to the Queen; but the territorial rights were secured to the natives. A small body of troops was landed soon afterwards; copies of the treaty were circulated throughout the land; and nearly all important native chiefs affixed their signatures to it.

The surveying vessel despatched by the New Zealand Company had been followed in due time by immigrant ships which brought settlers to enter into possession of the Company's purchases at Wellington. A meeting of a council representative of them took place in March, 1840, and rules were drawn up for the regulation and government of the settlement. Captain Hobson complained of these as high treason, and his Secretary, Shortland, went to Wellington in June, ordered the withdrawal of the regulations, and proclaimed the sovereignty of Queen Victoria.

The British flag was hoisted on the **South Island** and sovereignty proclaimed on 17th June, 1840. In July a French vessel, the *Comte de Paris,* arrived at the Bay of Islands with the avowed intention of establishing a French Colony in the South Island at Akaroa, where land had been purchased by a French whaler. While the French ship lay at the Bay of Islands, *H.M.S. Britomart* was despatched to Akaroa and, arriving there first, hoisted the British flag and proclaimed the land part of the British colony of New Zealand.

The capital of the colony was first fixed at **Russell,** but on the 21st February, 1840, Captain Hobson landed at the Waitemata, and several months later **Auckland** was established as the capital.

On November 16th, 1840, a **Charter** was issued for establishing the colony of **New Zealand,** providing for a legislative and elective council, and giving definite authority to the Governor. In this charter it was stated that the three islands were to be called New Ulster, New Munster, and New Leinster, but these names never had wide acceptance. On the 6th December Captain Hobson was appointed Governor, and the limits of the colony were proclaimed as between 34° 30′ and 47° 10′ S latitude and 166° 5′ and 179° E longitude.

In the early months of 1841, the land claims of the New Zealand Company formed a fruitful source of disagreement with the supreme authority in Auckland, but these were adjusted at the end of February, and further settlements were established. Some of the Wellington settlers bought allotments

of the Company's land at Wanganui and settled there in 1840. The New Zealand Company despatched more immigrants from Plymouth who landed in Taranaki on March 31st, 1841, and founded the settlement of New Plymouth. Another expedition organised by the Company left London and founded Nelson on February 1st, 1842.

In May, 1841, Captain Hobson's appointment as Governor of New Zealand reached the colony, and the Proclamation of the colony accordingly took place.

In 1842 the boundaries of the colony were enlarged so as to include all the outlying islands to the south and east.

In 1887 the Kermadecs were included within the boundaries of the colony of New Zealand. The last extension of New Zealand took place in 1901, when the "Cook and other Islands" were added. The exact limits of these areas are stated on p. 18.

Chapter IV.—THE PROVINCES.

The original settlements were evidently mainly determined, so far as the location is concerned, by geographical conditions. The northern settlement was first formed in the **Bay of Islands** because of its convenient situation with reference to the whale-fishing grounds and the forests of kauri timber. The change to **Auckland**, and the choice of this position as the site for the capital of the colony, was made because of the superior advantages possessed by a site which had harbours on both coasts of the

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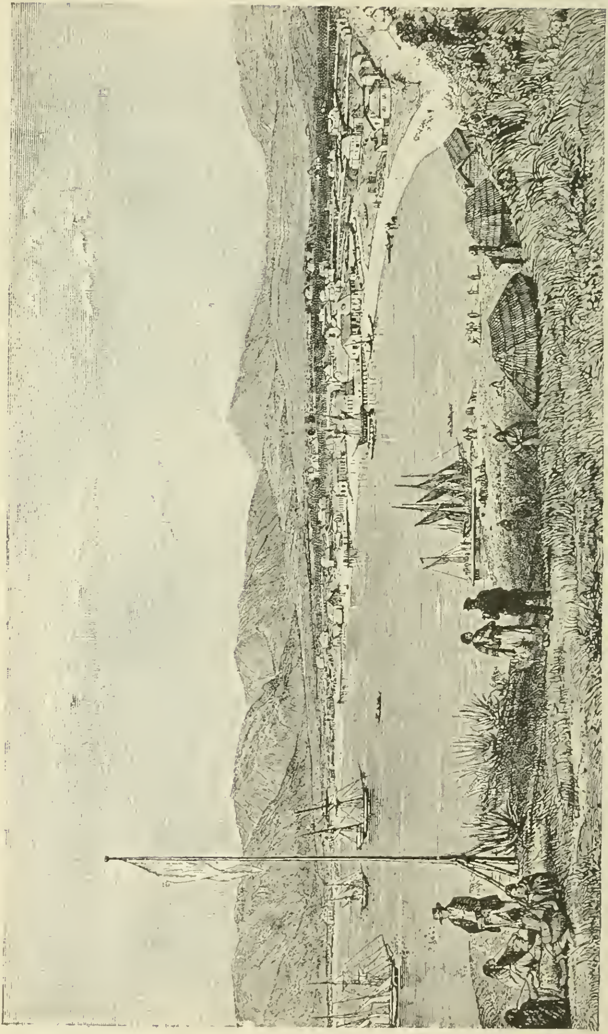


Old Wellington.

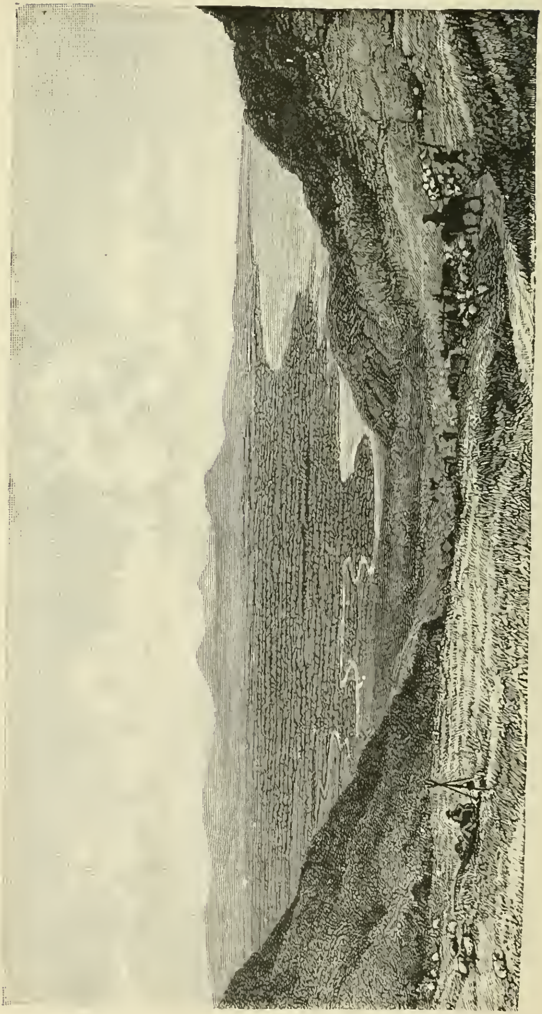
island and was within easy reach of the rich agricultural land of the Waikato.

The **New Plymouth** settlement was formed on the shores of the only available roadstead of the northern portion of the land bought by Wakefield as agent for the New Zealand Company.

Wellington was obviously suited by its position to be the commercial centre of all the purchases of the New Zealand Company. The level land of the Hutt valley formed the first attraction for the leader of the Company's colonising expeditions; but, as his purchases in land proceeded, it soon became evident that Wellington was destined to attain a larger size and far more importance, rather in consequence of its position with reference to surrounding coasts, than as a village supported by the agricultural industry of the Hutt valley.

Nelson was chosen for a settlement purely because of its geographical position. It was the only safe port that could be found in the western portion of Cook Strait, and it lay close to the fertile level land of the Waimea plain.

Dunedin and **Otago** were selected, in 1848, by an agent who passed by the Canterbury Plains before they had been settled, because he thought it would be impossible to reduce the low-lying, swampy land of the plains to a fit condition for agriculture. It is hard to see what advantages Dunedin possessed for settlers that were not possessed in far greater measure by Lyttelton. The surrounding hills, though certainly less lofty around Dunedin, were thickly covered with almost impenetrable forest nearly to the water's edge, and the plains beyond



The Canterbury Plains from the Bridle Path.—*From an old picture.*

them in the Taieri valley were more deeply covered with water than were the Canterbury Plains. Hardihood, perseverance, and resource were demanded of the old Otago settlers in no ordinary degree.

The **Canterbury** settlement was also formed because of the geographical advantages possessed by the site. The harbour at Lyttelton and the rich flat open plain beyond the Port Hills were sufficient to attract the pilgrims. This, the last of the special colonisation schemes, was effected in 1850.

These two southern settlements, like those at Wellington, Nelson, and New Plymouth, had been organised by the New Zealand Company, but more complete arrangements had been made for the reception of the settlers and for their occupation of the land than had been the case in connection with the earlier ventures. Each colonising expedition consisted of representatives of all grades of society, so that there should be no hindrance to speedy development. The Canterbury settlement, in particular, was constituted of representatives of all ranks and professions that are commonly to be found in a small country town in England, while the Dunedin settlement was as complete as a representation of Scotch society and life. The organisation and despatch of these settlements was, however, a great strain upon the resources of the New Zealand Company. Its promoters were to a large extent disappointed in their expectations with regard to the acquisition of land, and, though it is acknowledged on all hands that the administration of the Company was faulty, New Zealand owes a

deep sense of gratitude to those "greater Englanders" that shaped its policy. The crisis came in 1850. The Company could no longer fulfil its obligations. The New Zealand Government filled the breach, and took over all the rights, assets, and obligations of the Company for a sum that represented but a small portion of the money that had been contributed by the Company's shareholders.

Edward Gibbon Wakefield.

The original colonisation of a great part of New Zealand was thus effected by no mere haphazard aggregation of individuals of a roving disposition, but was the result of a set purpose and determination on the part of groups of artisans and farmers, who believed that residence in new lands and untilled fields would provide greater scope for their energies and activities than they were likely to find in Britain.

To the New Zealand Company, consisting of some men of eminence in state, church, and commerce, was this due; but the inspiration of the scheme and the energy and perseverance necessary to carry it into reality must be ascribed to **Edward Gibbon Wakefield.** Hampered by the Government in Eng-

land and by the newly appointed officers of the Crown in New Zealand, there is no room for surprise at the comparative failure of the undertaking from the Company's point of view. The fact remains that its colonising efforts resulted in the occupation of the land by a class of men animated by a desire to found in these distant latitudes a settlement, and, if need be, a state, in which they and their descendants as free Britons might evolve a new Southern Britain.

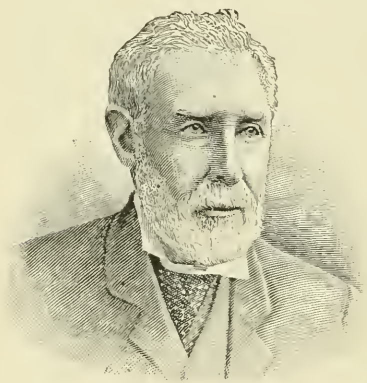
The six original settlements were at first almost completely isolated from one another. Communication was in most cases dependent on small coasting vessels whose voyages were precarious. Travelling by land was difficult—for rough country separated the settlements—and at times dangerous; and, in the absence of roads and bridges, walking was often the only means of reaching the neighbouring settlement. Even now the old barriers to commerce are not completely broken down, and Gisborne and Nelson still have no railway communication with any of the larger centres of population. The belt of bush separating New Plymouth from towns to the south of it has been comparatively lately opened to settlers. Canterbury and Otago have, however, long been united by road and railway.

This isolation has been to some extent responsible for the strong provincial feeling that has existed throughout the history of the colony, though now it is, fortunately, much modified.

Before 1853 the various centres were governed directly from Auckland, where the Governor resided. He was aided in his administration by a small

executive council. Considerable friction and trouble arose from the failure of the executive to grasp the different conditions and circumstances existing in the different settlements.

Governor Grey therefore brought into effect the **Constitution Act** of 1852. Each of the original settlements—Auckland, Taranaki, Wellington, Nelson, Otago, Canterbury—was constituted a Province, to be governed by an elective Provincial Council some of whose members formed a Provincial Executive under the Superintendent of the Province. Each Province elected some members for the House of Representatives of the whole colony, which met in Auckland. An upper house, or Legislative Council, was also formed of the Governor's nominees, and any measures passed by these legislative bodies had to receive the assent of the Governor.


Sir George Grey.

Land Troubles.—When first Governor Hobson commenced to control the colony, he decreed that no land titles other than those of the Crown could be recognised. This decree practically rendered landless all the colonists brought to New Zealand by the New Zealand Company, for the Company's

title was not granted by the Crown. After a Royal Commission had enquired into the question, a certain proportion of the land purchases from the natives was recognised, and a Crown title for this proportion was granted. In future all land was to be bought from the Maoris by the Crown and afterwards resold to settlers. This rule was, however, twice temporarily suspended.

It appears that the natives in many cases quite failed to understand that their ownership of the land entirely ceased when a sale had been effected, and hence arose from time to time many disputes between settlers who had bought land and natives who did not realise that they had sold it.

Land troubles also arose between the Provinces of Canterbury and Otago and the Central Government, because the latter sold all unoccupied land at 10s. an acre, whereas the provinces demanded £2 for each acre of their land, so that many settlers left these to make their homes where the land was cheaper.

Misunderstandings about land sale and occupation have been the chief causes of conflict between the settlers and the Maoris. In 1843 a survey party was attacked, and many were killed in the **Wairau**, in the Marlborough Province. In the Bay of Islands hostilities extended from 1844-6. But here the disaffection of the natives was due to the removal of the capital to Auckland with consequent loss of trade and prestige to the Bay of Islands. The imposition of custom duties increased the price of tobacco, etc. This was supposed by the natives to be associated with the erection of the flagstaff at

Kororareka. This was cut down, and when troops were sent, distrust and suspicion caused a serious outbreak. This was called **Heke's war**, from the prominent part played by a chief of that name in cutting down the flagstaff and sacking Kororareka.

In 1860 there was a more serious outbreak. Many of the North Island tribes, dissatisfied with the land purchases and with the attitude of the Europeans, established a confederation of Maori tribes. They elected a prominent chief as king, and made laws by which the tribes of the confederation would be bound. The land of these tribes was hence called the **King Country**. In Taranaki some land belonging to one of the tribes was thought to have been purchased for settlement by the Government. Disputes arising over it led to war, which, commencing in Taranaki, spread to the Waikato, then to the Bay of Plenty. Fostered by religious fanaticism—the so-called Hau Hau movement—the resistance on the west and east coast increased, and it was not until 1870 that it finally ceased.

Hone Heke.—*From an old print.*

This **Maori War** was first conducted by British troops, chiefly in the Waikato and Poverty Bay

districts. Ten Imperial regiments were represented under the command of General Cameron, but even in the early stages the assistance of volunteers and settlers was of great value. The Maoris were chased from stronghold to stronghold, and, despite many acts of heroism, they were finally crushed in the northern districts.

In the bush lands of Wanganui and Taranaki, a renewal of trouble took place. Religious fanaticism founded upon Christianity, debased however by many crude native superstitions, caused a recrudescence of the outbreak. The military ardour of the fanatics or Hau Haus was stimulated by the belief that, after the performance of mystic ceremonies and the incantation of dirges, the devotees became invulnerable to English bullets. First Wanganui and the West Coast towns were threatened, but the regulars under General Chute, stimulated by Sir George Grey, who was then Governor, successfully arrested the advance of the Maoris. On the East Coast there was a similar outbreak, which was also checked. In both instances the troops were greatly assisted by colonial volunteers, and the members of loyal native tribes. The last, on one occasion, on their own initiative attacked and overthrew at Moutoa, on the Wanganui River, a formidable band of Hau Haus proceeding with the expressed intention of sacking Wanganui.

Resistance was being gradually overcome when, in 1868, the Poverty Bay Massacre occurred. This was perpetrated by Te Kooti, a native prisoner who had been banished to the Chatham Islands. After organising a rebellion there, he had captured a

vessel, and landed in Poverty Bay. After this the war resolved itself into a chase of Te Kooti, who swept through the land like a firebrand. Fighting

Pehi Hitana Turoa, a Maori Chief, who was one of the leaders of the Hau-haus at the Battle of Moutoa.

on the colonial side was now, through the self-reliant policy of the Government, maintained solely by colonial troops, volunteers, and friendly natives. Though never captured, Te Kooti was so harassed

that his power was shattered, and, in 1870, he found shelter in the fastnesses of the King Country. A formal pardon was granted to him in 1883.

The campaign on the colonial side was conducted with great spirit under enormous difficulties, in country covered with semi-tropical primeval bush, by Colonel Whitmore, Colonel Macdonnell, and others, who had the very important assistance of Maori auxiliaries under Major Kemp (Kepa), Ropata, and other chiefs. Without their aid the campaign would have been greatly prolonged and much less successful.

Later Provinces.—The six provinces established by the Constitution Act of 1852 were added to in subsequent years, for important settlements were formed, either in outlying parts of the older provinces, or in districts not formally included within them. The geographical isolation of these settlements and the difficulty of communication made government by the existing Provincial Councils troublesome and unsatisfactory. The addition of more provinces seemed the only satisfactory solution of the difficulty. Marlborough 1859, Westland 1868, Hawke's Bay 1858, were the additions made. Southland for a time was separated from Otago, but was afterwards reunited.

Abolition.—Sir Julius Vogel, in 1876, succeeded in passing a measure in the Central Houses, by which the form of Government was completely changed. The development of the resources of the provinces required the expenditure of much borrowed money. The separate provinces could obtain this only at a ruinous rate of interest,

whereas the Central Government could borrow more cheaply. Sir Julius Vogel advocated rapid development, which needed rapid expenditure, and he showed the financial advantages that would be reaped if the provinces were abolished, and their affairs managed entirely by the Central Government. The capital of the colony had as early as 1865 been moved from Auckland to Wellington, and this town now became the seat of government for the whole colony. Geographically, and therefore commercially, the town of Wellington is the natural position for the capital of the colony.

Exploration.—During this development of the provinces, exploration proceeded gradually. No single name is specially connected with inland exploration throughout the colony. In the North Island Bishop Selwyn traversed much hitherto unknown land. The complete exploration of much of the "King Country," as that portion controlled by the Maori Confederation was long known, is still hardly completed.

The Urewera district inland from the East Cape has but recently been surveyed.

In the South Island adventurous settlers soon penetrated far into the recesses of the mountains, and discovered the lakes and grassy valleys that lie embosomed among them. But the West Coast was long a *terra incognita*, and it was not until after rich alluvial gold was discovered there in 1864 that any real knowledge of anything beyond the coast fringe was obtained.

In the south-west, where gold is less abundant,

there is still some rough mountainous country unexplored.

Were it not for the rich mineral wealth of the West Coast region, it is probable that even now the unexplored area would be large.

Part II.—PHYSICAL.

Chapter I.—LAND FORMS.

The surface configuration of the land is best understood by referring to it as composed of **positive** forms, or its solid projecting portions. Between and around these the **negative** land forms are gaps and depressions.

Positive land forms are **mountains, plateaus, plains.**

Negative land forms are **valleys, basins.**

Plains are level expanses of a land surface at no great height above the sea level. They are formed, either by the gradual deposit of matter that ultimately fills a previous hollow, or by the gradual planing away of an irregular surface until it becomes flat. The former are plains of **deposition,** the latter plains of **denudation.**

Coastal plains are plains of marine deposition. The bottom the sea is almost flat, and when it is elevated a flat land surface or plain results.

River plains are formed in river valleys in land that has been depressed. The rate of the flow of rivers in such land area is decreased, and the gravel brought by the tributaries cannot be removed by

the slow stream. It accumulates in the valleys, and forms river plains.

Similar plains are formed where rivers enter a lake or the sea, if they bring down gravel or finer material in large quantities.

Pene-plains are the planed surfaces that result from the wearing action of rivers upon a land surface. The rivers widen their valleys bit by bit, and in the end two or more valleys unite, and a continuous flat plain extends over the rough land that previously separated them.

A plain of marine denudation is made by the sea. The work of the sea is almost confined to its margin where the cliffs are gradually washed away. The action of the waves does not extend to any distance beneath the surface of the sea, so a flat area is formed which, when elevated, becomes a plain.

Mountains are prominent elevations.

Block mountains are formed by the breaking away and subsidence of the rocks around some portion that remains firm and is left as a prominent elevation.

Folded mountains are ridges of the earth's crust formed by the folds and complicated bends of its rocks. These are necessary in order to reduce the circumference of its crust so that it may still closely fit the interior, which is constantly shrinking as it cools. The actual form of such mountains depends far more on the effects of the destructive action of rain and rivers than on the shape of the rock-folds.

Residual mountains are the portions of a land surface that remain after it has been dissected by the river channels that cut through it.

When several mountains are arranged along a line, they constitute a **range.** From a range spurs usually jut out in various directions. These spurs should not properly be called ranges, though this term is often applied to them in New Zealand.

A series of ranges running nearly or quite parallel to one another constitute a mountain **chain.**

A Plateau is an elevated plain. Plateaus are usually less level than plains partly because of irregular movements during elevation, and partly because of the opportunity offered, in consequence of their elevated position, to running water to cut channels and destroy their evenness.

Valleys are depressions more or less steep-sided lying between elevated portions of the surface. Valleys are nearly always formed by the erosion of streams and rivers. When a valley slopes gradually to the sea coast and ends in a deep arm of the sea, which deepens gradually from its apex, it is termed a **ria.** A small stream valley is called a **gully,** and one with very steep sides a **gorge.**

A Fiord is a deep inlet which shallows towards its outlet as well as towards its apex.

Basins are valleys the outlets of which are blocked by comparatively high rock obstructions. They are formed in some cases by the rapid warping of the rocks of the district, when the lower end of a valley is raised more quickly than the upper end; or in other cases by the erosion of glacier ice, which is more active near its middle portion than at its terminal face. Basins may be partly or wholly occupied by lakes or by small river plains formed of material by which lakes have been filled.

Chapter II.—THE NEW ZEALAND COAST.

The **general trend** of the New Zealand coast line is from north-east to south-west. This is the dominant direction of the two longest coast lines of the South Island and of the east coast of the southern portion of the North Island. The other

Sloping Marine Shelf, Otago Peninsula. At the top of the cliffs is a terrace that marks a former sea level.

prominent coast direction is from north-west to south-east. The simple combination of these two directions gives the South Island the form of a parallelogram. In the North Island the north-west and south-east direction is more prominent than the other, especially in the northern portion. A north-west prolongation of its north end results.

Whilst the general trend of the coast line is comparatively simple, it is equally true that the coast is not, on the whole, broken by the presence of islands or of deep inlets. Remarkable exceptions to this statement are, however, found in the region of the West Coast Sounds of the South Island, in the Queen Charlotte Sounds, and on the east coast of the Auckland Province.

In most parts of the country the inlets into the land are comparatively shallow, and clearly represent submerged portions of stream valleys that were eroded during a previous period of greater elevation. At the same time there may be seen on many parts of the coast marine terraces clearly indicating that during a period not long past the land was at a lower level. Of the two positions the latter appears to have been the more recent, and, judging by the relative height of the terraces above the present sea level, the depression was greater in the south than in the north. A mere general inspection of the coast line therefore shows that the country was some time ago much more elevated than now. The period of elevation was succeeded by one of depression, and the last movement has been one of gradual elevation.

We must therefore expect to find that the New Zealand coast line presents predominantly the features of a coast recently elevated, though in some districts the effects of the previous submergences are still most conspicuous.

The south-west-north-east direction is parallel to the direction of the dominant mountain range which

is the most characteristic feature of all Pacific coast lines. The north-west direction of the North Auckland coast line is parallel to the direction of the Western Pacific ridge extending from New Caledonia to New Zealand.

The north-west-south-east direction of the coast line in Cook Strait and Foveaux Strait and of the eastern portion of Poverty Bay extends at right angles to the line of mountain elevation, and it is here that the most rugged and precipitous coast scenery is to be found.

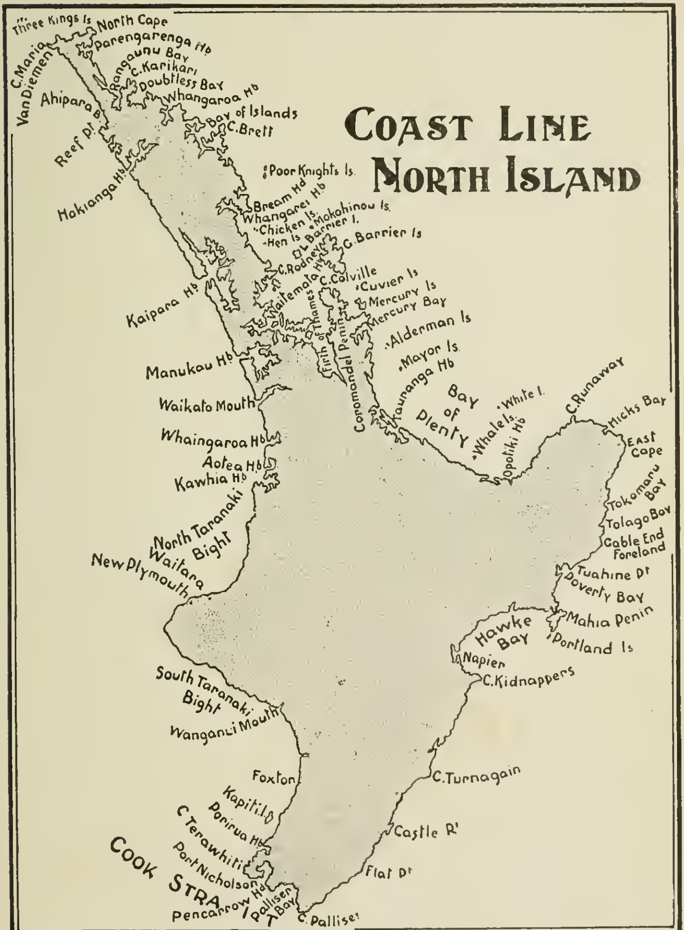
The North Island Coast.

The coast line of the North Island is far more irregular in its broader features than that of the South. The divisions of the coast are here classified according to the direction to which they face.

The **South Coast**, 40 miles in length, extends from Cape Terawhiti to Cape Palliser. Port Nicholson and Palliser Bay, the former with a narrow—the latter with a broad entrance, reach far into the land.

The **South-east Coast**, 325 miles in length, extends from Cape Palliser to East Cape. Hawke Bay is a broad shallow indentation. There are many more smaller bays further north, but none of them makes any serious break in the general regularity of this coast.

The **North Coast**, 225 miles in length from East Cape to Auckland, is divided into the two principal regions of the Bay of Plenty and the Hauraki Gulf by the projecting Coromandel Peninsula.


COAST LINE
NORTH ISLAND
Three Kings Is
North Cape
Parengarenga Hb
Rangaunu Bay
C. Karikari
Doubtless Bay
Whangaroa Hb
Bay of Islands
C. Brett
C. Maria
Van Diemen
Ahipara B.
Reef Pt
Hokianga Hb
Poor Knights Is.
Bream Hd
Whangarei Hb
Chicken Is
Mokohinou Is.
Hen Is
L. Barrier I.
G. Barrier Is
C. Rodney
C. Colville
Waitemata Hb
Cuvier Is
Mercury Is
Mercury Bay
Kaipara Hb
Firth of Thames
Coromandel Penin
Alderman Is
Mayor Is.
Tauranga Hb
Manukau Hb
Waikato Mouth
Bay of Plenty
White I.
Whale Is
Opotiki Hb
C. Runaway
Hicks Bay
East Cape
Whaingaroa Hb
Aotea Hb
Kawhia Hb
North Taranaki Bight
Waitara
New Plymouth
Tokomaru Bay
Tolago Bay
Cable End Foreland
Tuahine Pt
Poverty Bay
Mahia Penin
Portland Is
Hawke Bay
Napier
C. Kidnappers
South Taranaki Bight
Wanganui Mouth
Foxton
C. Turnagain
Kapiti I.
Porirua Hb
C. Terawhiti
Port Nicholson
Castle Pt
Flat Pt
COOK STRAIT
Pencarrow Hd
Palliser Bay
C. Palliser

The **North-east Coast,** 195 miles in length, extends from Auckland to North Cape.

The **South-west and West Coast,** 560 miles in length, extending from Cape Maria Van Diemen to Cape Terawhiti. In its northern portion, it is comparatively unbroken, though there are several widely extending inlets, such as Kaipara Harbour, with very narrow entrances. The Mt. Egmont promontory is a conspicuous point projecting westwards. It divides the North from the South Taranaki Bight. The coast line from the South Taranaki Bight to Cape Terawhiti forms a portion of the north-east coast of Cook Strait.

The total length of the coast line of the North Island is 1,345 miles. This estimate does not include the length of curves round the small inlets.

The **South Coast** is composed of shale* rocks. These have a precipitous seaward face which rises almost immediately into high wooded hills. At the base of the cliffs, one or more rock terraces are to be seen. These have certainly been formed by the cutting action of the sea when the land stood at a lower level.

The lowest of these terraces marks the height of the sea level before 1855. In this year a violent earthquake occurred, and the coast line from Wellington to Palliser Bay was elevated permanently to a height of from 5 to 9ft. above its previous level. At the head of Palliser Bay there is a low shingle plain composed of gravel brought down by the Ruamahanga River from the eastern flanks of the Tararua Mountains.

*The term shale is used here as a general term for rocks of Maitai age. They are often sandstones or greywackes.

Port Nicholson is a commodious harbour. A narrow deep entrance leads into a deep water basin almost completely land locked. It is a portion of the Hutt valley, formed by the Hutt River, that has been submerged owing to a depression of the land. Cape Terawhiti, Pencarrow Head, and Cape Palliser are the important capes on the coast. There are no outlying islands; but the small rocky Some's Island is situated in Port Nicholson.

The **South-east Coast** is in its southern portion formed of shale rocks, and has the same character as the south coast. From Flat Point northwards the coast is formed throughout of soft Cainozoic and later rocks. It has everywhere the appearance and structure usual with such formations. The land near the coast is comparatively low, and ends in abrupt cliffs of marl and mudstone, at the base of which there is usually a narrow beach except at the headlands.

From Cape Palliser to Cape Kidnappers the coast is very little broken. The rivers that enter the sea are small, and empty themselves into small bays that provide little or no shelter for shipping.

The large rounded indentation of Hawke Bay is entered by several larger rivers, but they afford no harbours, except in the case of the Tutaekuri River, whose estuary can be entered by light draught vessels. An artificial breakwater has been constructed at Napier for the protection of shipping. The southern portion of Hawke Bay has a gravel coast line, bordered by flat low country. The gravel has been deposited by the numerous rivers flowing

The Spit, Napier.

out from the Kaimanawa and Ruahine Mountains.

As in the case of other coasts, the shingle is brought down more rapidly than the sea can remove it, and forms bars and spits across the river entrances.

The Mahia Peninsula, which forms the northern boundary of Hawke Bay is joined to the mainland by a narrow stretch of low sandhills. Off its southern

extremity Portland Island is situated. There are no other islands on this part of the coast.

The coast from Mahia to East Cape is steeper and more broken. Poverty Bay is the deepest inlet. It affords fair shelter for shipping in most weather. At its head is a small gravel plain. Tokomaru Bay and Tolago Bay are the other larger inlets. Tuahine Point, Gable End Foreland, and East Cape are the most prominent capes.

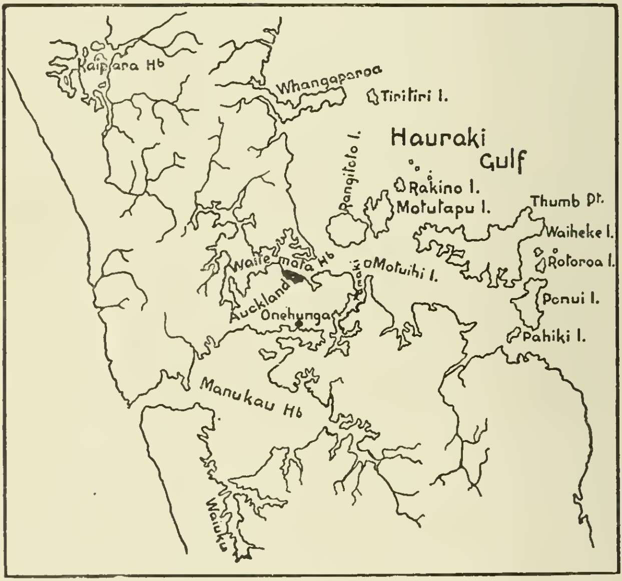
The **Northern Coast** is at its eastern end abrupt and precipitous. The coast truncates the backbone range of the North Island, so the country rises rapidly from the coast line, which is fringed with steep shale cliffs similar to those on the south coast, though more rugged. Near Opotiki its character changes completely.

Hicks Bay is a deep inlet near the eastern end of this region, and Cape Runaway is the most projecting cape.

From Opotiki to Mercury Bay the coast line is fringed with volcanic material. For nearly the whole of this distance it is flat and low, though here and there the solid lava sheets have been cut back into steep cliffs—a feature that is especially noticeable between Tauranga and Mercury Bay on the eastern side of the Coromandel Peninsula. Several rivers of fairly large size enter the Bay of Plenty, but they are all obstructed by bars, and only small vessels can trade to them. Tauranga Harbour has a wide extent, but is extremely shallow. Mercury Bay affords better facilities for shipping. It is a submerged stream valley.

There are several outlying islands on this coast. They are nearly all volcanic, and one of them, White Island, is still active. The others are Whale Island, Mayor Island, and the Alderman Islands.

The rest of the northern coast line from Mercury Bay to Auckland is highly varied in nature and



Scale: 1 inch = 14 miles.
Map of Auckland Isthmus and neighbouring coast: a typical submerged coast line. All the streams valleys end in rias.

structure. A small portion of the coast of the Coromandel Peninsula is composed of shale rocks, and in its high steep cliffs recalls the appearance of the south coast of this island. Volcanic rocks are, however more frequent. They produce a coast line rather similar to that of the shale rocks. At the head

of the Firth of Thames a low plain extends far inland, and fronts the coast with a level beach. From this point slate rocks are again encountered, and they in turn yield to Cainozoic clays and mudstones near Auckland, where there are occasional volcanic formations on the coast line.

Outlying islands are numerous. The Great Barrier is a continuation of the Coromandel Peninsula in structure and position, and is separated from it by

Rangitoto Island: a typical volcanic cone.

a strait 11 miles wide. Mercury Islands, off the east coast of Coromandel, are volcanic. Ponui and Waiheke Islands in the Hauraki Gulf are formed of shale rocks. Motutapu is Cainozoic, anl Rangitoto is a perfect miniature volcano, 900 feet high.

The prominent capes are Cape Colville, at the north end of the Coromandel Peninsula; Cape Barrier, on the south end of Great Barrier; and Thumb Point on Waiheke.

The whole inner portion of the Hauraki Gulf provides good anchorage for shipping, and the Waitemata Harbour, which penetrates far into the land

at the head of the gulf—the Auckland Isthmus—provides good accommodation for shipping of all sizes. Inlets in this coast are numerous. They are for the most part shallow, with wide-spreading mud flats at their inner ends and at their sides, and in all respects have the typical form of rias. They are certainly drowned river valleys, and the absence of terraces round the shore line proves that in this northern district re-elevation has not yet commenced. The Firth of Thames, Coromandel Harbour, Tamaki River, and Waitemata Harbour are the most important.

The **North-east Coast** stretching from Auckland to the North Cape is the most broken and diversified of all the North Island Coast. There are sudden changes in the rock structure from volcanic to Cainozoic and to shale with which is often associated as sudden a change in the character of the scenery and coastal forms.

For the first 40 miles north of Auckland the coast is of the usual Cainozoic type,—low country, low cliffs, with a fringe of beach. Then shale rocks with their type of coast extend almost continuously to Doubtless Bay, but at Whangarei the great Bream Head is of volcanic rock.

North of Doubtless Bay the coast is chiefly low sandhills until slates and other older rocks are again encountered two miles south of North Cape, whence they extend across the extreme north and down the west coast a little south of Cape Maria van Diemen.

Bays and harbours along this coast are numerous. Whangarei Harbour, Bay of Islands, Whangaroa Harbour, Doubtless Bay, Rangaunu Bay, and

Parengarenga Harbour are the largest. They have the same character as those of the coast line last described, and have been formed in the same way.

The coast line has abundance of projecting points and rugged capes, of which Cape Rodney, Bream

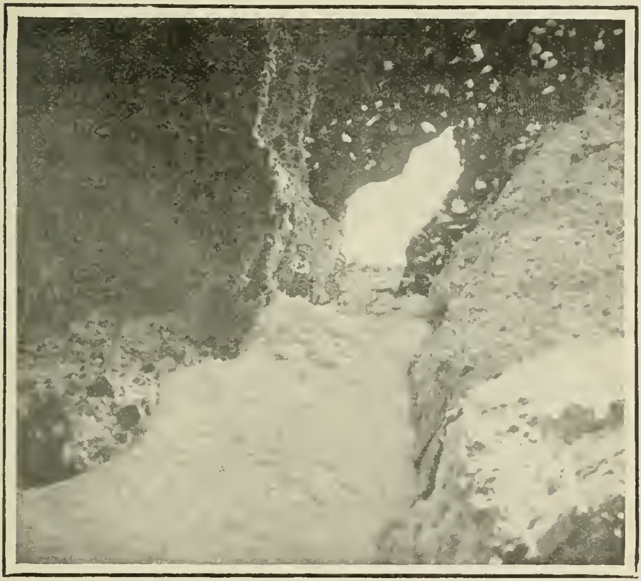


Photo by G. Mulgan

The Big Blow Hole, Manukau.

Head, Cape Brett, Cape Karikari, and North Cape are the most prominent.

Outlying islands are numerous. Tiritiri, Kawau, Hen and Chicken Islands, Poor Knights, and Cavalli Islands are the largest of them. Mokohinau Island, an isolated rock to the north of the Great Barrier, has a lighthouse erected on it.

The short stretch of **Northern Coast** has no harbours. It ends in Cape North on the east side and in Cape Maria Van Diemen on the west. Near the latter is Cape Reinga a place of much importance in Maori tradition.

South-west and West Coast.—From Cape Maria van Diemen to Raglan Harbour the coast faces with an almost unbroken line to the south-west. For the greater portion of this distance it is faced with rolling sandhills, which stretch completely across the narrow portion of the island north of Ahipara Bay. Reef Point, south of this bay, has the typical form of shale coast, and this is found again at the South Waikato Head and at Albatross Head. North of the Manukau there is the usual form that is found wherever Cainozoic country reaches the coast line. Volcanic rocks form high steep cliffs sometimes 500 feet in altitude with little or no beach at their base at Maunganui Bluff, and between Manukau and Kaipara Harbours, and further south between Raglan and Aotea Harbours. There are no outlying islands, but there are several large and shallow harbours. In most of these there are deep water channels sometimes close to the shore. Across the entrance of all of them are huge sand banks. The sand is black, and contains a high percentage of oxide of iron. It is derived from the volcanic rocks which stretch along such a distance of the coast.

The sand, urged by wave, current and wind, drifts up the coast, and always tends to block completely the entrances to these harbours. The strong ebb tide sweeps the material out seawards, but still the drift

continues. In this way sand-banks stretching four miles out to sea have been formed outside the Manukau, and off the Kaipara entrance they extend out seven miles. These sandbanks constitute a serious and treacherous menace to vessels. They render harbours that are otherwise deep and commodious almost useless for accommodation of shipping.

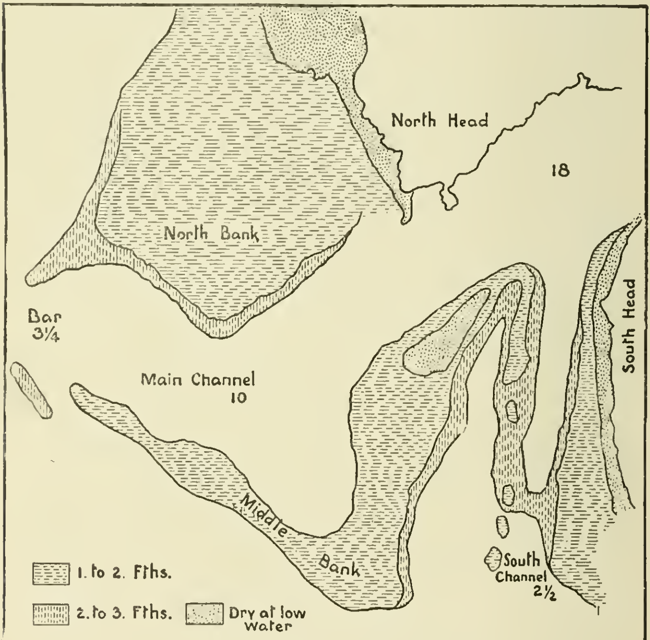
Deep channels course through these harbours with almost the same perfection of branching tributaries as in a river system on a land surface. There is no doubt that the same land depression that it was stated accounted for the formation of the harbours in the north-east side of the island has also produced those on this south-west coast. The heavy seas and constant drift on the western side have alone rendered them of such little utility compared with those on the eastern side.

The most important of these inlets are Whangape, Hokianga, Kaipara, Manukau, Whaingaroa, and Aotea. The entrance of the Waikato River is of a similar nature, but within the sand bar there is not the wide area of tidal waters that is so characteristic of the other inlets.

Reef Point, Maunganui Bluff, and Woody Head are the only prominent points.

From Aotea Harbour to New Plymouth, that is, throughout the North Taranaki Bight the Cainozoic coast line prevails except for a short distance on both sides of Albatross Head where shale rocks form their characteristic coast. Rolling sand dunes form the coast line near the entrances of harbours or rivers. Kawhia Harbour, the only important inlet,

has characters in all essential respects similar to those of Kaipara and other West Coast harbours. The only island off this part of the coast is Gannet Island, an isolated rock 15 miles north of Albatross Head. At New Plymouth the small volcanic rocks forming the Sugarloafs are conspicuous islets.



Scale : ¾ inch = 1 mile.
Map of entrance to Manukau Harbour, showing sand banks and bar.

South of New Plymouth the coast line is fringed with volcanic rocks. Here, however, the sea has not worn the hills back into steep beetling cliffs as is often the case in New Zealand. The cliffs are comparatively low, but the land rises quickly behind

them. There are no inlets and no capes except Cape Egmont.

Further southward to the mouth of the Wangaehu River the Cainozoic type of coast is well displayed. At the mouth of every river and stream, rolling sandhills are blown slowly inland and form a waste of dunes. There are no prominent capes, and the river entrances are here, as elsewhere, nearly closed by shifting bars of black sand formed of material brought down by the rivers from the volcanic mountains in which they take their rise.

South of the Wangaehu the coast is everywhere formed of black sand dunes, and the bars impede navigation of all the rivers, but near Porirua the shale rocks are again encountered, and with slight interruptions of Cainozoic coast extend south to Cape Terawhiti.

There are two islands off this coast, Kapiti and Mana. The former has the typical shale coast and the latter the Cainozoic. The nature of the coast line with its shifting sand between Egmont and Porirua entirely prohibits the formation of capes or harbours. Porirua Harbour, which first breaks it, is situated in the slate rocks.

Chapter III.—THE NEW ZEALAND COAST.

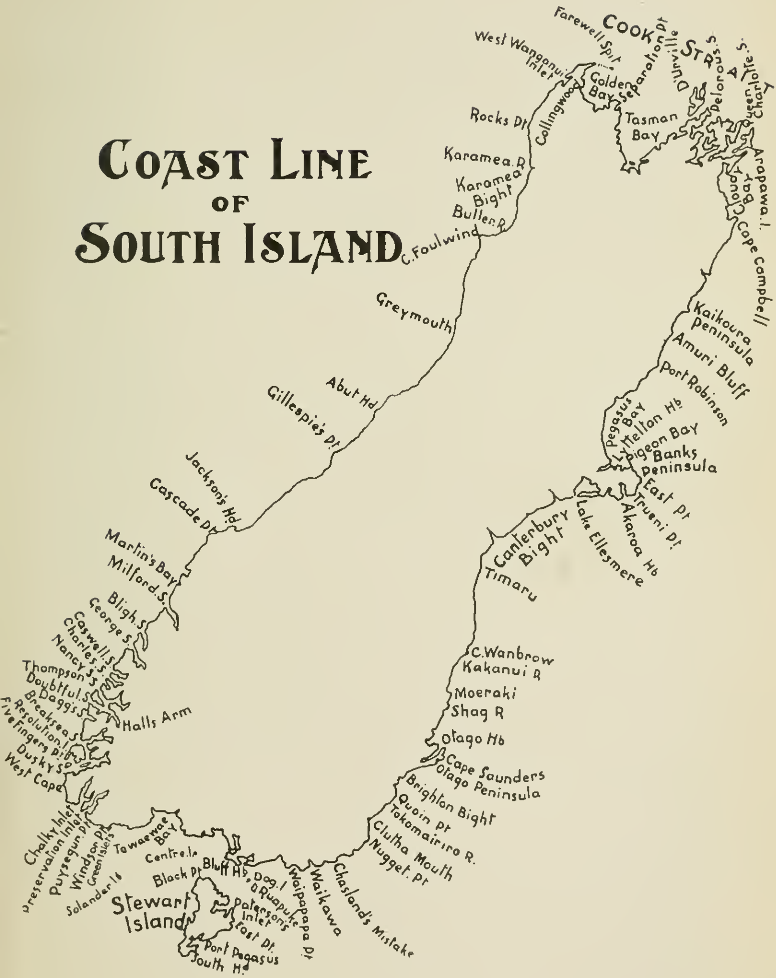
PART II.

The South Island Coast.

The **east coast of the South Island** is especially regular. In its extreme southern portion it is nearly at right angles to the easterly extension of the Hokonui Hills. The rocks are sandstone and shales. They have been worn into broad, shallow inlets, separated by stern, steep promontories. At the Nuggets—the most northerly extension of the hills and of the rock type—the strata stand up vertically and project into the sea as narrow, rugged pinnacles.

The Clutha enters the sea through a valley some five or six miles wide, faced on the sea side by a beach formed of material brought down by the river. Thence to the Otago Peninsula the coast line is steep but not high, fringed at the base, with a rock terrace cut by the sea when the land was lower, and with a beach still partly composed of material supplied by the Clutha: but, as we proceed northwards from the river mouth, the pebbles are broken down, the softer minerals removed as mud, and, finally, only the hard white quartz remains, as the Otago Peninsula is reached.

The most important headlands on this part of the coast are Waipapa Point, Chasland's Mistake, and Nugget Point. The more important bays are Waikawa, Molyneux, into which the Clutha flows, and the Brighton Bight.


COAST LINE OF SOUTH ISLAND
COOK STRAIT
Farewell Spit
West Wanganui Inlet
Separation Pt
D'Urville I.
Pelorous S.
Queen Charlotte S.
Golden Bay
Collingwood
Tasman Bay
Rocks Pt
Karamea R
Karamea Bight
Buller R
C. Foulwind
Arapawa I.
Cloudy Bay
Cape Campbell
Greymouth
Kaikoura Peninsula
Amuri Bluff
Port Robinson
Abut Hd
Gillespie's Pt
Pegasus Bay
Lyttelton Hb
Pigeon Bay
Banks Peninsula
East Pt
Trueni Pt
Akaroa Hb
Lake Ellesmere
Canterbury Bight
Timaru
Jackson's Hd
Cascade Pt
Martin's Bay
Milford S.
Bligh S.
George S.
Caswell S.
Charles S.
Nancy S.
Thompson S.
Doubtful S.
Dagg's S.
Breaksea S.
Resolution I.
Five fingers Pt
Dusky S.
West Cape
Halls Arm
C. Wanbrow
Kakanui R
Moeraki
Shag R
Otago Hb
Cape Saunders
Otago Peninsula
Brighton Bight
Quoin Pt
Tokomairiro R.
Clutha Mouth
Nugget Pt
Chaslands Mistake
Waikawa
Waipapapa Pt
Chalky Inlet
Preservation Inlet
Puysegur Pt
Windsor Pt
Green Islets
Towaewae Bay
Centre I.
Solander Is
Black Pt
Bluff Hb
Dog I
Ruapuke
Stewart Island
Paterson's Inlet
East Pt
Port Pegasus
South Hd

From the Tokomairiro River to the Shag River the coast line cuts at right angles the great south-east-north-west mountain axis of Otago. No striking coastal effects are produced by this, for the folded rocks of this mountain range are for the most part fringed by much later formations, which form a gradual declivity to the coast. Where this fringe is absent, the country still is low, for the mountain range was reduced to the condition of a pene-plain at a remote epoch.

The Otago Peninsula is entirely volcanic, and the hard rocks have opposed such a formidable barrier to the ocean waves that high precipitous cliffs have been formed on every headland, below which no beaches extend. Yet the white quartz sand is rolled onwards and accumulates in all the more shallow bays. It has extended as a bar across all the broader inlets, and constitutes a serious menace to the navigation of Otago Harbour, the most important of them. The most projecting headlands on the peninsula are Cape Saunders and Taiaroa Head.

From a point a short distance north of the peninsula to Timaru the coast is everywhere fringed by soft Cainozoic formations, which form low cliffs, generally with a narrow beach, except at the base of the more projecting headlands. In the southern portion this consists of sand, but to the north of the Waitaki it is a rough shingle beach supplied by the material that the Waitaki and other rivers roll down.

The most important capes are Shag Point, Moeraki Point, and Cape Wanbrow.

Sketch of Otago Harbour and Peninsula from Mount Cargill. 1. Taiaroa Head. 2. Sandspit. 3. Port Chalmers. 4. Portobello Peninsula. 5. Mount Charles. 6. Papanui Inlet with Sandspit on left. 7. Hooper's Inlet, with Sandspit on left

North of Timaru the Ninety-mile Beach commences and stretches with an uninterrupted sweep to Banks Peninsula. The beach is a gravel one, composed of material that the mountain rivers of Canterbury are constantly carrying down from the Southern Alps. Like the sand further south, the gravel is carried northwards by the ocean current, and is finally deposited against the opposing buttress of Banks Peninsula. The deflection of the current by the Peninsula has caused the enclosure of Lake Ellesmere, a salt water lagoon.

The greater mass of Banks Peninsula and the coarseness of the gravel, which is less easily drifted than sand, have prevented the drift from blocking up the inlets in Banks Peninsula in the manner in which those in Otago Peninsula have been choked up. Still

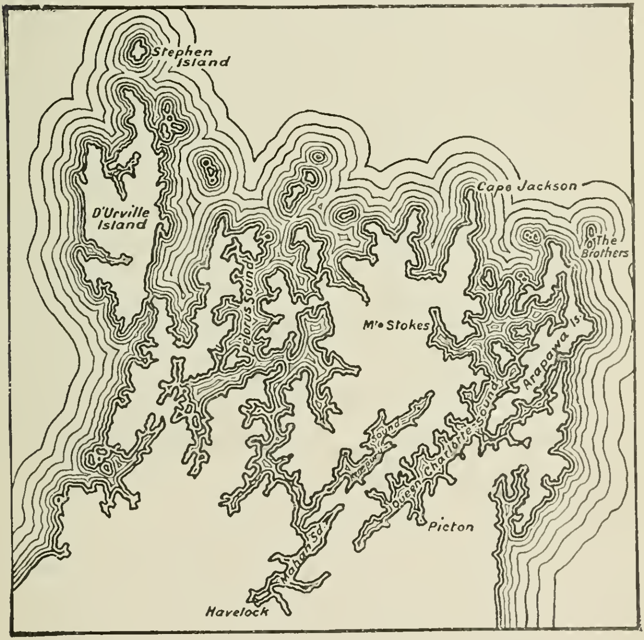
the encroachment has been considerable, and has already blocked up Lake Forsyth, which was once an inlet similar to what Akaroa Harbour is now. On Banks Peninsula, Trueni Head, East Head, and Godley Head are the most prominent points; and Akaroa Harbour, Pigeon Bay, and Lyttelton Harbour the best known inlets.

The general nature of the coast line of Banks Peninsula is similar to that already described of Otago Peninsula, except that the spits of sand are absent.

A sandy beach extends for some distance to the north of the Peninsula, and soon it becomes backed by soft Cainozoic rocks, which extend with intervals of slates to Cape Campbell and into Cloudy Bay, where they are temporarily replaced by the gravels deposited by the Wairau. The Amuri Bluff, Kaikoura Peninsula, and Cape Campbell are the most prominent points in an even coast line, and Port Robinson and Kaikoura Harbour the best known, though extremely small, inlets.

Northern Coast of the South Island.—From Cloudy Bay to Nelson, at the head of Tasman Bay, the coast line crosses the northern continuation of the Southern Alps. It is the most broken portion of the coast line of New Zealand. Numerous small outlying rocky islands form the continuation of ridges that inland divide deep far-reaching inlets from one another. This coast line is a typical instance of the broken nature that results from depression of a high mountainous land in which deep river valleys have been eroded.

The shape of the sounds is typical of the shapes of river valleys in a well developed drainage system. Each little gully extending down the hill-side between adjacent spurs ends in its separate small arm of the sound into which it falls. Queen



Map of Queen Charlotte and Pelorus Sounds, showing typical submerged river systems.

Charlotte Sound and Pelorus Sound are the two great inlets in this coast line. Each of them reaches about 28 miles into the land, and the highly branched development that is such a prominent feature of them is realised to some extent when it

Kenepuru, Pelorus Sound.

is stated that the actual coast line of Pelorus Sound followed round all the small branches and arms is 237 miles. The water in the sounds is uniformly between twenty and thirty fathoms in depth. There is a safe and sheltered anchorage here for steamers which are at times unable to navigate Cook Strait in the heavy weather that is sometimes experienced.

Westward from Nelson, the granite coast is soon reached. Here small shallow inlets, showing mud banks at low tide are frequent. These are separated by bold granite bluffs. The presence of the inlets shows that the sea level is now higher than when the stream valleys were eroded, but they appear to have been partly filled up when the sea level was higher than at present.

The granite coast extends almost to Takaka. The shore of Golden Bay beyond is similar to that bounding the Cainozoic country on the east coast.

Of the islands on this northern coast of the South Island, D'Urville, Stephen, The Brothers, and Arapawa, are most important. Arapawa Island is separated from the mainland by Tory Channel, and D'Urville Island by the French Pass. Through both of these narrow channels the flood tide flows with great rapidity, as much as 7 miles per hour, but small coasting steamers navigate both of them.

The important Capes are Jackson, Lambert, Clay Point, Stephen, and Separation Point.

The extreme north point of the South Island is Cape Farewell. It is continued out almost due east into Cook Strait as a long sandy spit 14 miles long. The material of which this is composed has been

French Pass.

Photo, Muir & Moody

brought along the west coast by the southerly swell and currents that sweep northwards.

From Cape Farewell down the **west coast** to Cape Foulwind, the shore line is little indented. The coast is variable in its nature, usually steep, and in places with little beach. Inlets are few, comparatively shallow, and useless for shipping ports. The West Wanganui inlet, and the entrance to the Karamea and to the Buller River are the only places where vessels can enter. Rocks Point is the most prominent cape. It is formed of a hard pink granite.

South of Greymouth, the character of the coast changes, and gravel beaches stretch as far as Bruce Bay. A narrow strip of flat coastal plain borders the land. It is similar in nature and formation to the Canterbury plains on the other side of the island. Here, however, glacial action has been more prominent and in many places glacial moraines form bold bluffs fronting the sea. The large angular boulders stick out from the finer material in a very conspicuous manner. The only ports on the coast to which vessels can trade are the river mouths, but as these places are always partly blocked by bars, only smaller steamers can enter them. Abut Head is the most prominent cape.

Further southwards the character of the coast again changes and steep country with a narrow fringing beach is encountered. Near the mouth of the Haast there is again a gravel plain, repeating the character of the coastal plain further north. Thence steep country prevails, till Milford Sound is reached. In many places on this portion of the

coast, old terraces can be seen that clearly indicate a recent gradual land elevation through some hundreds of feet. Cascade Point is a prominent projecting head.

The coast from Milford Sound to Preservation Inlet is much broken. The high mountainous land here reaches the sea coast, and is in fact truncated

Dea's Cove, Thompson Sound. The rounded rocks above the vessel's mast have been worn by a glacier. The water in the sound is here 1500 feet deep.

by it. Deep inlets, sometimes reaching as far as 30 miles into the land, are frequent. These inlets are steep-sided above and below water. In some places mountain peaks 5,000 feet high rise almost sheer from the water's side, and the precipitous slope may be continued for 1,000 feet beneath the water level. These inlets are true fiords or sounds; compared

with the Queen Charlotte and Pelorus Sounds, they are narrow, steep-sided and deep, and little broken by curves and branches.

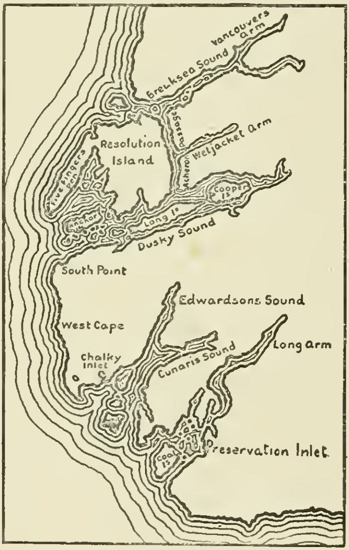
It is evident that some different agent has acted here, and has at any rate completed the final moulding of these profound valleys.

The soundings show a remarkable fact—the fiords are deepest in their central portions and comparatively shallow at the entrances. This shallowness cannot be ascribed to the same action that accounted for the formation of the more northerly river bars. Here, there is no constant supply of shingle, and no spits of gravel project from either the North or the South Head of any of the sounds. The rounded and smooth surface of so many of the hills and islands show clearly that huge glaciers have filled these deep depressions. It is probable that these glaciers, with their stupendous weight of slowly flowing ice are responsible for the excavation of all the West Coast Sounds.

The same controversy that has raged around the origin of many mountain lakes, has extended to the **origin of fiords**, and nearly all authorities admit that the same cause has accounted for the formation of both. Opinions as to what this cause may be are ranged round two camps of geological thought. The one explains fiord formation as resulting from the gradual wearing action of glaciers. The other states that fiords are merely river valleys whose lower ends have been submerged. The existence of the deeper central portion is explained by the supposition that the submergence was not the result of a uniform movement of depression—but that the

inner, higher, and heavier mountains subside more rapidly than the outer. This has resulted in the formation of eanoe shaped fiords, shallow at the mouths.

In this southern portion of New Zealand, the similarity of some mountain lakes to fiords is especially well shown; for the arms of Te Anau and Manapouri possess in all their details all the peculiarities so prominent in the fiords themselves.



- The Southern Fiords or Sounds. The comparatively straight unbranched character is very noticeable when compared with the map of Queen Charlotte Sound, on page 75.

While the Queen Charlotte Sounds are simply depressed stream valleys, the West Coast Fiords are clearly depressed glacial valleys. Here again the presence of terraces at Milford Sound in the north, and Preservation Inlet in the south, proves that the latest movement has been one of elevation, but the elevation has not been great enough to obliterate the effeets of previous depression. The eharaeter of the eoast line is clearly that of a land

Milford Sound, with Mitre Peak

which at a greater elevation was scarred, and seamed by the denuding agents of Nature, and then depressed to such an extent that the seams have become inlets of the sea.

The **principal fiords** from the north southwards, are Milford, Bligh, George, Caswell, Charles, Nancy, Thompson, Doubtful, Daggs, Breaksea, Dusky, and Chalky and Preservation Inlets. The most prominent capes are West Cape, Five Fingers Point, and Puysegur Cape.

The actual coast fronting the ocean is not a very steep one, but is covered everywhere by a thick mantle of vegetation. This in itself proves that the land is gradually moving up or down, otherwise the ceaseless roll of the Southern Ocean would have formed high and steep cliffs. The freshness of the terraces indicates that the movement is one of elevation.

In places some of the fiords unite; thus Resolution and Secretary Islands are separated from the mainland, the one by Thompson Sound, the other by Acheron Passage.

The **southern coast** is in its westerly portion, fringed by many elevated marine terraces. Seven well formed and distinct examples, situated one over the other, can be seen near the Green Islets. They end in rather abrupt cliffs with narrow beaches below them. Further east after passing Tewaewae Bay, the gravel plains of Southland are met with. They are fronted by a low gravel beach.

Rather numerous islands are formed on this part of the coast. They are small granite outliers. Some of them lie in the direct track of the steamer

Hall's Arm, Milford Sound.

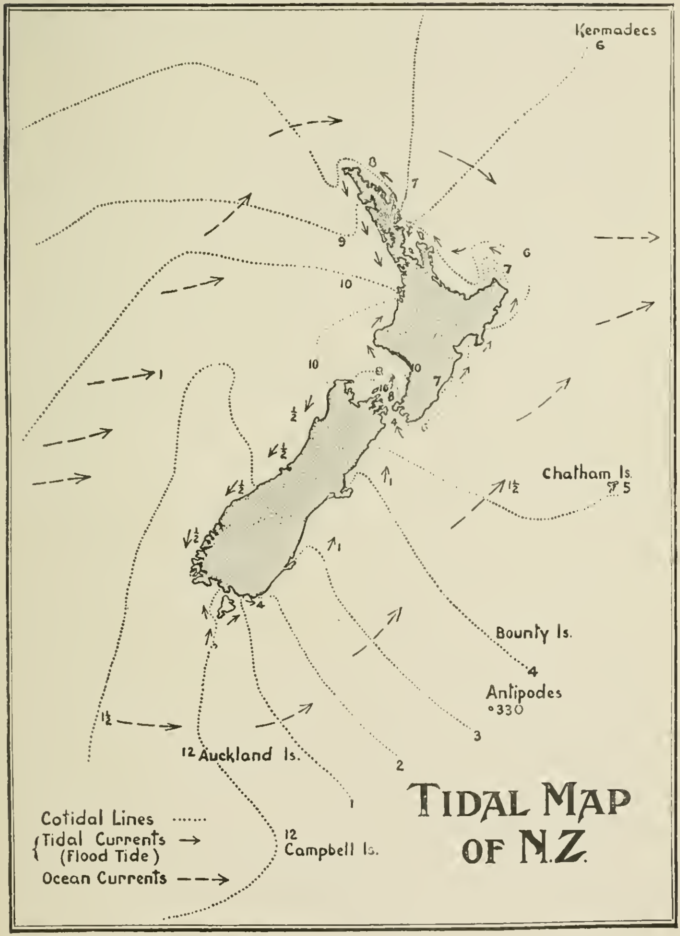
traffic between New Zealand and Australia. The Solanders, Centre Island, Dog Island, and Ruapuke are the best known. Windsor Point, the Bluff, and Waipapa Point are the most important capes. The Bluff Harbour is the only inlet that admits large ships, but smaller craft can enter the mouth of the New River and reach Invercargill.

The **coast of Stewart Island** is similar to that of the West Coast Sounds region; but the inlets do not penetrate so far and their sides are not so precipitous. Paterson's Inlet and Port Pegasus are perfect harbours for large or small craft. South Cape, East Head, and Black Point are prominent capes. The numerous outlying islands are small and rocky.

Tides.

The attraction exercised by the moon on the earth causes the ocean to bulge out towards it. As the earth rotates and the moon appears to move from east to west, the bulge in the ocean subsides. Thus is generated a tidal wave, which has a period of about 12½ hours. The movement of these tidal waves causes the ocean margin to rise and fall at every spot on the shore twice in twenty-five hours.

The sun has a similar attractive action and so have all other celestial bodies, though their effect is less marked, because they are much further away than the moon, and further away or immensely smaller than the sun. When the sun and moon are in the same (new moon) or in exactly opposite directions (full moon) in the sky, the waves they generate become coincident, and the resultant tidal


Kermadecs
6
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◦330
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2
1
12 Auckland Is.
12
Campbell Is.
Cotidal Lines
Tidal Currents (Flood Tide)
Ocean Currents
TIDAL MAP OF N.Z.

wave reaches its greatest height. These are **spring tides.** When the moon is halfway between the positions alongside and opposite the sun, the waves they generate interfere with one another, and the lowest or **neap tides** result.

Where this low heaving wave meets any land mass, it wells round its coast, and its direction and height undergo great change. Currents of some power and velocity are generated especially round projecting points of the land or through straits that separate two land masses from each another. In New Zealand, for instance, the tidal stream that flows round East Cape has a velocity of 3 knots per hour, while in Foveaux Strait, and Cook Strait it reaches at times 5 knots, and in the French Pass and Tory Channel, 7 knots per hour. The height that the tidal wave reaches is from five to six feet from low water to high water in the open ocean, but on an extensive coast line its rise is very much greater. It is especially great in those inlets that have a wide opening to the ocean and contract gradually to a narrow head. In the Bay of Fundy, Canada, an inlet of this nature, the difference between high and low water at spring tides reaches 50 feet, but such a height is altogether exceptional. In New Zealand the height is seldom more than 15 feet, and probably never more than 20.

In estuaries the huge wave, invisible in open seas because of its gradual slope, may become visible as its waters are slowly closed in. The advance of the flood or inflowing tide is then marked by a **bore**, a rushing, roaring wave, destructive to all small craft. In China, in the Tsientang, a bore

reaches the height of 15 feet. In New Zealand, there is a small bore in the Kaipara Harbour, beyond Dargaville.

The map on page 87 shows the direction of **co-tidal lines** in New Zealand. These are the imaginary lines that connect different places where high tides occur at the same time, and the successive co-tidal lines mark the progress of the tidal wave from hour to hour. It will be seen that the arrangement of the land in the Southern Pacific has a great influence on the direction of the tidal wave. In New Zealand, the tidal wave commences at Stewart Island, and flows from south-east to north-west. Its crest is at first almost north and south, but at Banks Peninsula it extends east and west to the Chatham Islands, and afterwards swings further round until at North Cape it is north-west and south-east. Its direction still further changes in the Tasman Sea until it has the north and south direction again at the south. New Zealand thus appears to be a pivot round which the tidal wave swings. Some of the tidal wave passes through Cook Strait and a portion advancing north meets near Kawhia the portion that passed round North Cape. Another portion reinforces the northern wave and sweeps south with it. At East Cape and at Stephen Island high water is not reached until two hours after the main wave has swept past. The rush of water past these points is so great that the full effect is not seen until after the basin of the Bay of Plenty or Tasman Bay into which it flows is full, and the flow of water is checked. In Wellington Harbour the tide rises only 3¼ feet,

and is full nearly two hours sooner than in Cook Strait outside the Harbour. The water rises but little in the harbour after the flow through Cook Strait has commenced.

Much of the trade in New Zealand ports is dependent upon the tides. On the bars of the West Coast ports in particular, and even in Dunedin, Timaru, Oamaru, and Bluff, the vessels that visit the ports can navigate the waters only when the tide is full.

Influence of the Coast Line upon the Distribution of Population.

The fact that the products of New Zealand are for the most part consumed abroad invests those inlets in the coast line that are adapted for harbours with great importance. It is true that contour of the coast line is not the matter of greatest moment, for the inlets in New Zealand that possess the greatest area of sheltered water and the greatest depth are still absolutely uninhabited. More important than these is the position of the inlet with reference to fertile tracts of land or to the larger centres of production.

Of the many fine natural harbours that New Zealand possesses, only two of the first class, Auckland and Wellington are so geographically situated that they have been utilised as the sites of large towns. Harbours that, from the point of view of navigators, are by nature second class, have been converted into deep-water sheltered harbours by human industry. Especially is this the case at

West Part of Wellington Harbour.

Lyttelton, Dunedin, Bluff, and Napier. The superb natural harbours of the Pelorus and Queen Charlotte Sounds, and the magnificent fiords of the south-west are, on account of their less favoured geographical position or remoteness from areas of pastoral and agricultural value, almost entirely forsaken. Good instances of this are found in the south-west fiords; but Picton and Havelock, in the other sound area, have become minor centres of industry. If the size of vessels trading to New Zealand ever reaches that of the Atlantic liners it is probable that one of the harbours in the Queen Charlotte Sounds will become the distributing centre.

The wide but shallow harbours at Kaipara, Manukau, Kawhia and elsewhere are apparently at no time destined to support a large population. The Bay of Islands at one time was the centre of all New Zealand trade; but the greater advantages possessed by Auckland were speedily realised, and the township of Russell has advanced comparatively but little in the last half century.

The bars already described as extending across the entrances to all the large rivers have effectually prevented the towns situated at these points from rising to the importance that their position at first sight seems to warrant. At Westport and Greymouth the valuable mineral deposits, and at Wanganui the large area of rich pastoral and agricultural land have forced the settlers to make use of the treacherous river entrances as the only available outlet for their produce. The Waikato mouth, though as navigable as these, is entirely neglected, because of its proximity to Auckland with

which the Waikato valley is connected by railway. With few exceptions the magnificent natural harbours with which the land is endowed are uninhabited, while the sea coast bordering the fertile lands for long stretches offers no opportunity for the coming and going of vessels. Thus for 400 miles the fertile land of the east coast of the South Island is destitute of any natural harbours, that without artificial breakwaters or dredging provide satisfactory accommodation for commerce.

The fishing population on the coast is small and is chiefly concentrated near the larger ports where a ready market is obtained. At Stewart Island the oyster and "cod" fisheries support a small population, for whom the coast line provides first-class harbours. At Moeraki there is a small fishing population.

In former times a large whale fishery supported populations in coastal districts that are now almost entirely deserted. At the present time the New Zealand coast line is, in general, little populated, though in places where rich valleys reach the sea isolated stations or small hamlets have sprung up.

Chapter IV.—MOUNTAINS OF NEW ZEALAND.

No very exact definition can be given of the term mountain. A mere statement of elevation is insufficient. There are in New Zealand elevated plains, such as the Mackenzie Plains, which reach almost two thousand feet above sea level and the hills on their surface would, if near the sea coast and isolated, fully deserve the term mountain. In some of the higher portions of the Southern Alps there are many ridges that have an elevation of 4,000 feet or more, but they are so entirely dwarfed by the larger mountains around them that they have not even locally been dignified by the name mountain. On the other hand several of the little volcanic hills near Auckland are so isolated and stand out so prominently from the low-lying land around them that they are always spoken of as mountains. Mount Eden is only 540 feet high and Mount Rangitoto, which rises directly from the sea level is 920 feet in altitude. We must be content with the very general definition that a mountain is an elevation that rises conspicuously above the natural features surrounding it.

These conspicuous elevations or mountains may originate in very different ways.

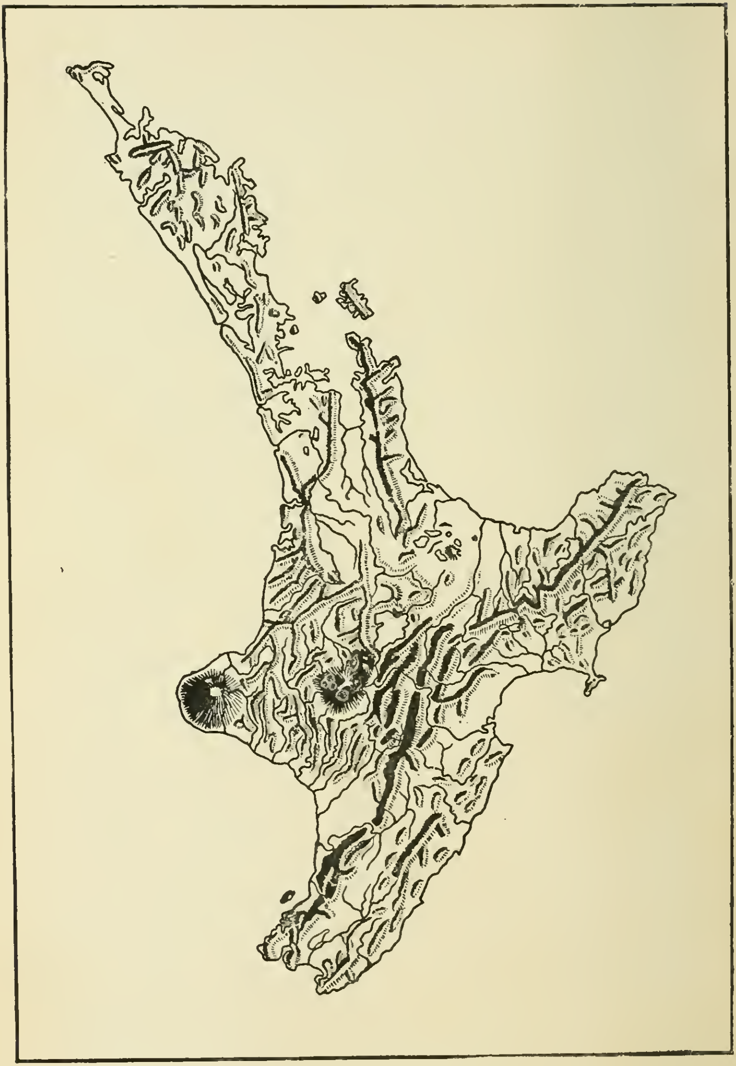
Block mountains result from the subsidence of large portions of the earth's crust along lines of rock fracture. Those portions that do not participate in the movement stand out as steep-sided flat-topped mountains. This type is not well represented in New Zealand.

Volcanic mountains are treated in a subsequent chapter.

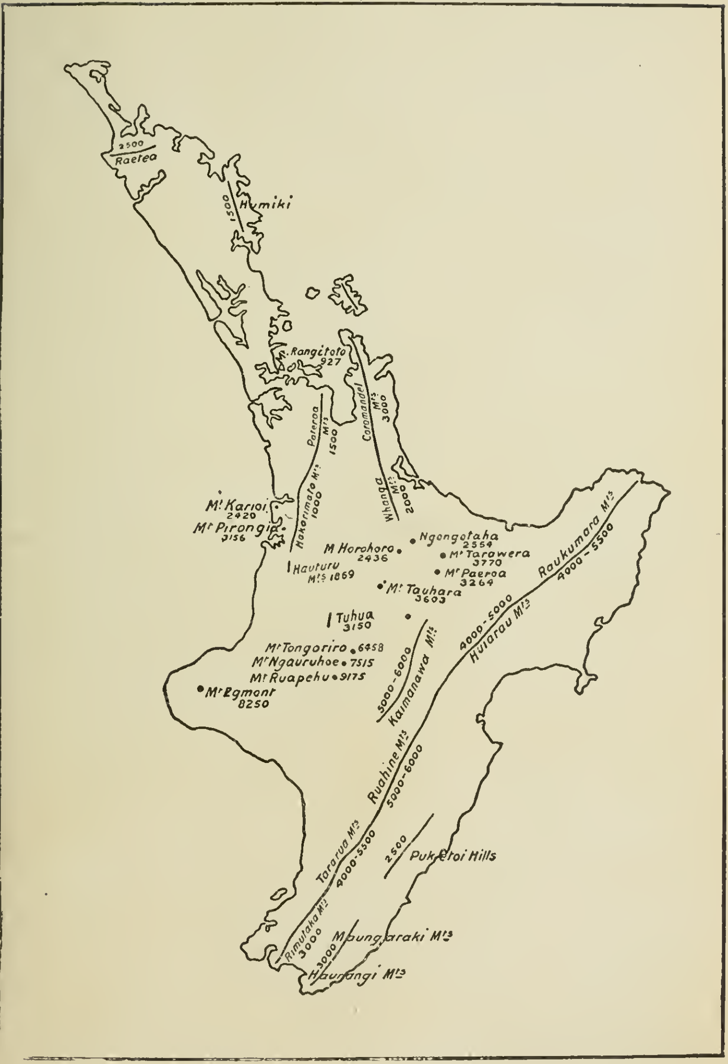
Residual mountains.—If a flat land surface is elevated and remains at a high level for many ages, the streams that course over its surface will finally so cut it up into ridges and valleys that at last the only remaining portions of the original flat surface will be the summits of the mountains. The Wanganui plain of marine deposition affords an example of this action in its less advanced stages, and the mountains of Central Otago an example of a more mature stage.

Folded mountains form the great mountain districts of the world. As the heated interior of the earth gradually cools and contracts, the crust has to adjust itself to a nucleus that slowly becomes smaller. The adjustment is performed by a crumpling or folding of the older formed crust. The layers of rock are bent or folded into a varied succession of arches and troughs—so called, anticlines and synclines—of great variety of form and of sharpness of bend. As the folding proceeds, local elevation takes place and, even whilst its formation is in progress, the mountainous area is being furrowed and dissected into valleys and gorges by the streams fed by the copious rains that fall in nearly all mountain districts. After a time elevation ceases. Then the destruction wrought by the rain and streams gains the mastery and the mountain range bit by bit crumbles to ruin.

It often happens that the crests of the rock folds are worn into deep valleys, while the troughs which are hardened and compressed by folding stand out



Semi-relief Map of North Island, indicating the position and relative height of mountains.



Key to semi-relief Map giving names and elevations of more important mountains.

as mountain crests. More often there is no apparent relation between the structural characters and those developed by the action of the weather.

Mountains of the North Island.

The mountains of the North Island are less elevated and less numerous than those of the south. A continuous range extends from Wellington to the East Cape. Near Wellington it is called the **Rimutaka**, then the **Tararua.** North of the Manawatu Gorge it is the **Ruahine**, then **Kaimanawa, Huiarau,** and finally **Raukumara** Mountains near the East Cape.

This range is nowhere more than 6,000 feet high, and in many places its crest does not rise above the level to which bush can grow. Throughout the greater part of its length it is narrow, but expands to a great width (40 miles) in the Kaimanawa Mountains, and in the East Cape district. The relation of this range to the general structure of the land is not thoroughly understood. On the one hand, Suess follows Hochstetter in stating that the range is a continuation of the Kaikoura Range in the South Island. The map at once shows that these ranges have the same general direction. The peculiar structure mentioned below as occurring in the Kaikouras has never been noticed in the North Island "backbone," as this mountain range has been called.

Other observers have pointed out that the mountain axis of the South Island, if continued across Cook Strait, would pass through the centre of the

Roto Kiri o Pupae, Waikare Moana: showing some spurs of Huiarau Mts.

North Island in a direction parallel to, though at some distance from, the "backbone" of the island. This relative position they have taken to indicate that the "backbone" may correspond with some of the lower ridges on the eastern side of the Southern Alps, while the centre of the range has been entirely removed by the wearing action of weather and running water, or has subsided along planes of rock fracture. Along its lines of fracture volcanic action broke out afterwards.

The range is formed of folded rocks and the strata stand nearly vertical. The occurrence of similar rocks on the other side of the broad volcanic zone of Taupo is perhaps an indication that the rock folds extended at one time right across the intervening volcanic country, but have been worn away and removed in accordance with the view given above.

Hochstetter, in 1865, recorded the presence of folded rocks similar to those of the Ruahine Mountains in the Hauturu Mountains and Tuhua and in other elevations on the west of Taupo. These are, however, isolated, though to the north of Pirongia a connected range of low altitude extends northward to Wairoa and into the islands of the Hauraki Gulf. This, according to most geologists, represents the western flank of a continuous and extensive mountain chain that at one time extended uninterruptedly across the present volcanic belt to the "backbone" of the island, which at that time was the eastern flank of the mountain chain. Further north small outcrops of similar folded rocks occur at various localities; for instance, north of Whangarei and around the Bay of Islands. These

do not, as has been supposed, represent the remnants of a range of mountains previously forming a connected ridge in the direction of the present trend of the Northern Peninsula. They are the isolated trunks of old and worn ranges that had a direction more or less parallel to the existing mountains.

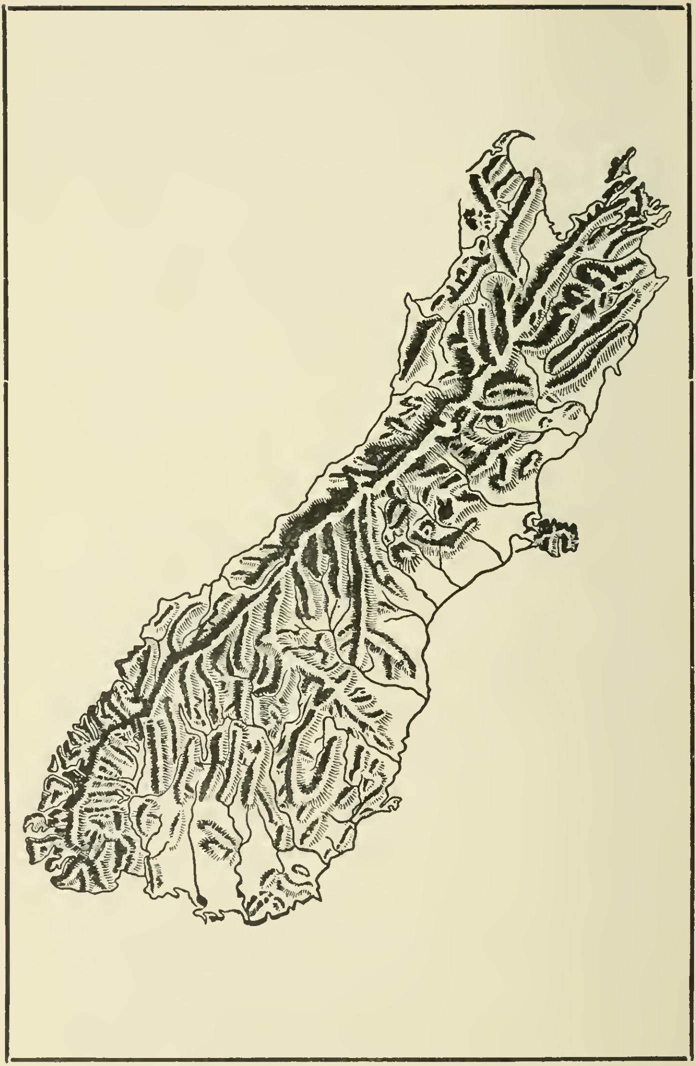
The other mountain ranges of the North Island are insignificant. The **Cape Colville** Range, extending from Te Aroha to the north of the Great Barrier Island, is a remnant similar to the range from Pirongia to Wairoa, but volcanic eruptions of a more recent date than that of its origin have added greatly to its bulk, and are mainly responsible for its present altitude of 2,900 feet.

On the east side of the Wellington and Hawke's Bay Provinces, hills, rather than mountains, of very recent age form prominent objects in the landscape. Of these, the **Puketois** now constitute a portion of the main watershed between the east and west coasts, for the "backbone" of the island is broken through by the Manawatu River, and the watershed pushed further to the east.

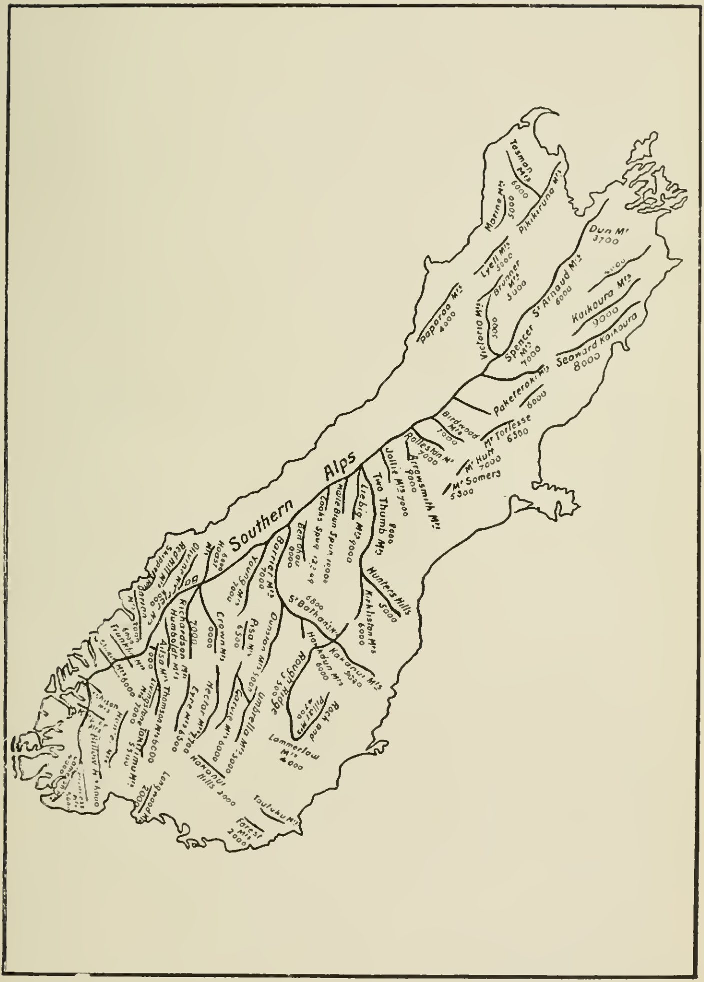
The Puketois are a young range, and the rocks of which they are formed are lying almost flat, and do not possess the complicated folded structure of the "backbone."

The **Maungaraki** Range, of greater antiquity, extends from Cape Palliser for some distance to the north. It represents again a portion of the old outlying ranges parallel to the "backbone."

The mountains having the greatest altitudes in the North Island are not included in this enumeration



Semi-relief Map of South Island, indicating the position and relative height of mountains.



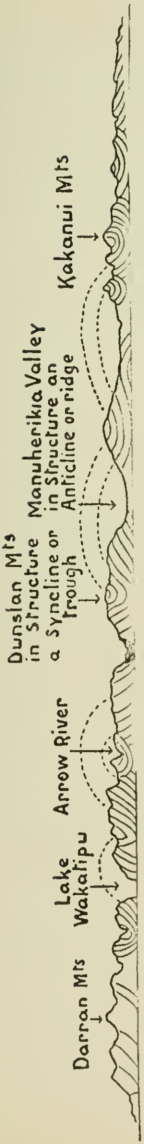
Key to semi-relief Map giving names and elevations of more important mountains.

of mountain ranges. for they are volcanic in nature and origin, and require separate treatment.

Mountains of the South Island.

Folded Mountains are the most noticeable feature of all portions of the South Island. In every locality in the island from which on clear days a wide view can be obtained, the horizon in one or more directions is bounded by a high and commanding mountain ridge. In no cases are the mountain summits the true structural crest of the great folds into which the crushing forces of earth movement have compressed the crust. Here, as in many mountainous regions, the structural troughs or synclines often form the topographic mountain ridges.

The main mountain chain of the South Island is called the **Southern Alps**. It extends throughout the length of the island from Windsor Point in the south-west to Cape Soucis in the north. Its direction is almost exactly north-east to south-west in nearly a straight line. In the extreme south the mountain crests have such a uniform elevation of about 5,000 feet as to produce the impression that the area is an ancient plateau, but dissected in all parts by profound gorges and river valleys. The Southern Alps are crossed by several low passes, such as Mackinnon Pass, which is used for the tourist track from Lake Te Anau to Milford Sound. Further north the range becomes narrower, but increases in altitude passing in the north of Otago through Mount Aspiring, 9,960 feet. In Canterbury the altitude becomes still greater, though the Southern



From Sir J. Hector's diagram, showing the folds in the New Zealand rocks, from Milford Sound to Oamaru Cape. The dotted lines show the continuation of these folds. All the dotted portion has been removed by natural agencies.

Alps are in the south of the province crossed by Haast Pass, 1800 feet, but on each side the mountain crests rise to over 5,000 feet. In the central part of its length it attains its greatest altitude and includes the crests of Mount Cook, 12,359 feet, Sefton, 10,350, Tasman, 11,467, and many others more than 10,000 feet high, but even here the Fitzgerald Pass is only 7,000 feet. Further north the altitude decreases and several low passes are found, one of which—Arthur's Pass 3,013 feet—is used for the road connecting Christchurch and Greymouth.

In the extreme north of the Canterbury Province and the south of the Nelson Province the Southern Alps again expand and form a large area of mountain ridges with numerous peaks, many of which exceed an altitude of 7,000 feet; Mount Franklin, 7,571 feet, is the highest of

Top 3000 feet of Mount Cook. Photo taken from the ice plateau at elevation of 9000 feet.

several nearly equal altitudes. From this region, known as the Spencer Mountains, onward its elevation generally decreases and few peaks exceeding 4,000 feet are found for some distance before Cook Strait is reached.

This great mountain chain preserves its integrity throughout, for though the watershed is driven first to one side of the chain then to the other, by the development of various river basins, there is not one that can be said to pierce it; for though many rivers, such as the Haast, cross some of the lower ranges and drain longitudinal valleys there is always some ridge that effectually prevents further encroachment.

It was previously said that this range of high elevation is not the true structural axis of the folds of the earth's crust. Examination of its component rocks and of their arrangement shows us that throughout its length there are on the eastern side a large number of smaller rock folds, the rocks of which show evidence of greater and greater age as the highest ridge is approached, and this continues after its crest has been passed. It is only when the lower western slopes are reached that the oldest rocks are found. The structure of other mountain ranges is rather different, for in nearly all cases there are lower ridges of younger rocks on each side of the main ridge, which is itself composed of the oldest found in the series. The old rocks are found in the centre of the range because, in this elevated and steep portion, the wearing action of rain and streams soon removes the younger rocks that originally covered them and exposes the ancient

rocks below. The occurrence of the oldest rocks near the West Coast therefore gives us reason to think that a large part of the western development of the Southern Alps has been removed and that the great mountain system that still remains is only the eastern portion of the original earthfold.

In the northern portion of the range some part of this western development remains and forms another range of some dimensions. It extends from Golden Bay nearly to Greymouth. The range is nearly straight throughout its length, but gives off large spurs to the west. To the south-east about twenty miles south of Golden Bay, it is united to the **Tasman** range, which runs south from Golden Bay and generally maintains a course nearly parallel to that of the Southern Alps. It is completely breached by the deep gorge of the Buller River. Different parts of this range are called the **Pikikiruna** Mountains, **Aopouri** Range, the **Lyell** Range, and the **Paparoa Range.**

There are other ranges of great importance in the South Island. In its northern part, the **Kaikouras,** of which there are two parallel ridges reaching to 9,467 feet in Tapuaenuka, the highest peak, appear to be the continuation of the North Island mountains. The Kaikouras, though apparently isolated ridges, in reality continue on the other side of the Waiau and Hanmer Plains to Mount Ajax on the main range of the Southern Alps.

In Canterbury and Otago the main Southern Alps are connected with several mountain ridges running generally north-north-east and south-south-west. There are two very short ridges, really only

mountain spurs, of this nature in the central alpine region. On one of these Mount Cook is situated, and on another Mount Darwin and Mount Malte

Mount Malte Brun, 10,421 feet, with Tasman Glacier at base.
Photo from slope of Mount Cook, 6,000 feet.

Brun. There is a much longer ridge starting at Mount Tyndall, to the north of the Murchison glacier. It passes through the **Two Thumb** Mountains, the **Kirkliston** Mountains, the **Rough Ridge**,

and finally the **Lammermoor**. Here it turns north-north-east again and forms the **Lammerlaw** and **Rock and Pillar** Range. One branch from this ridge forms the **Hunters Hills**. At Mount Ida it is crossed by a transverse ridge passing from Mount Strauchan on the main range to the **Kakanui** Mountains. Another north-north-east to south-south-west ridge leaves the transverse one near Lindis Pass and forms the **Dunstan** Mountains and the **Umbrella** Mountains. Four other well defined parallel ridges further to the west can also be distinguished. The most easterly of these consists of the **Young** Mountains, **Pisa** Mountains, **Carrick** Mountains, and **Garvie** Mountains. The next, leaving the Southern Alps at Mount Aspiring, forms at first the **Crown** Mountains and, after passing Frankton, the **Remarkables** and **Hector** Mountains. The third also leaves the Southern Alps at Mount Aspiring and forms the **Richardson** Mountains and **Eyre** Mountains. The last ridge forms the **Ailsa** Mountains, the **Livingstone** Mountains and the **Takitimus**. It leaves the Southern Alps south of Greenstone Saddle.

The majority of these mountain ridges in Otago have a north and south direction, and appear at first sight to be a series of parallel ranges, forming together a mountain chain whose main axis of elevation is parallel to the crests of the ridges.

Detailed examination shows that such a view is entirely erroneous; for the arrangement of the rocks clearly indicates that the main axis of elevation is directed from south-east to north-west extending from Dunedin to Mount Aspiring, a

The Remarkables, from Queenstown.

direction nearly parallel to the transverse ridge from Mount Strauchan to the Kakanui Mountains and to the ridge of the Hokonuis.

A noticeable point in all these mountains of Otago east of the main axis of the South Island is the comparatively low altitude of the mountain tops. Very few of them, such as the Double Cone of the Remarkables, rise above 7,000 feet. The vast majority lie between 4,000 and 6,000, and their number is almost legion.

The rocks of which all these ranges are composed have such a nature that it is evident they have at one time been buried beneath thousands of feet of overlying rock. When thus deeply buried, the rocks were folded by the enormous lateral pressure caused by the contraction of a cooling globe, and the level of the land remained 6,000 or 7,000 feet below its present level. On this land surface the activity of running water finally worked out a peneplain.

An elevation to the present level enabled consequent streams again to run off the surface of the land, and commence again that destructive action which is the main characteristic of all streams. The course of these streams was north and south. They excavated deep valleys, and, finally, the only trace that remained of the peneplain formed by an older generation of rivers was to be found in the uniformity of the altitude of the mountain tops.

Central Otago is, in the phrase of the geologist, "a dissected peneplain of extreme antiquity."

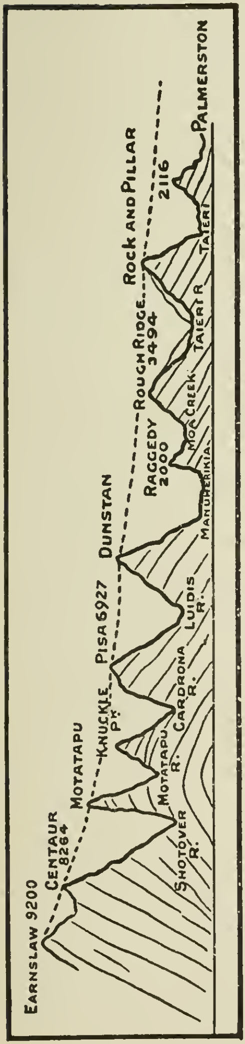
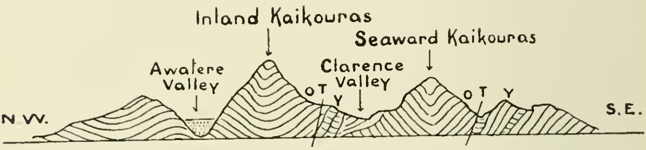


Diagram across Otago Mountains from West to East. The dotted line is the surface of the peneplain after elevation and erosion. Scale: Horizontal, 1 in. equals 30 miles; Vertical, 1 in. equals 10,000 feet.

So far as the structure of the **Kaikouras** is known, they appear to owe their elevation to other and different influences from those that have elevated the Southern Alps. The officers of the Geological Survey assert that an inclined plane of rock fracture, or a reversed fault, is to be seen in the Clarence valley between the two ranges, and in the valley between the Inland Kaikouras and the Awatere Hills beyond. Immense pressure acting from the north-west has thrust the rocks of which the mountains are formed bodily along this inclined plane, and it is to this lateral movement rather than to folding that they owe their present elevation.

This bare statement of the numbers and arrangement of the South Island mountains gives a very inadequate idea of the extremely rugged nature

of much of the land. Though the statement that the mountain axis is near the west coast throughout the greater part of the island is correct, it must always be borne in mind that spurs, often of sufficient elevation and length themselves to constitute ranges, extend east and west. Especially is this the case in Canterbury, where the outlying mountains forming the western border of the plains are sometimes fifty miles east of the axis, and even at this distance some of their peaks attain an altitude of over 6,000 feet. Mount Hutt, the highest of these eastern mountains, is 7,180 feet high. It



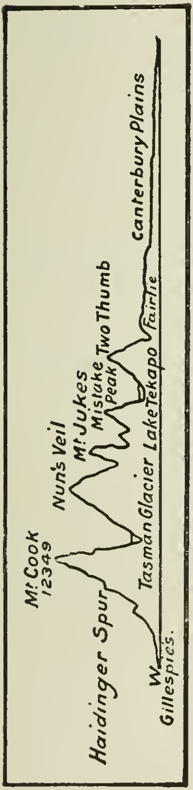
From McKay's diagram of Kaikouras. T, planes of rock fracture The old rocks (O) on the north-west side have been thrust by pressure over the young rocks (Y) on the south-east side.

can truly be said that five-sixths of the whole of the South Island is mountainous. In the south-west of the island some of the mountainous districts are so inaccessible that large areas exist which are as yet wholly unexplored.

Stewart Island is also, for the greater part, rugged and even mountainous: but the highest point, Mount Anglem, is only 3,200 feet high, and few of the other peaks exceed 2,000 feet.

Though the statement is made here that the unilateral structure of the Southern Alps is due to

removal of the eastern portion by marine erosion, there are many authorities who regard this structure as original. Suess, for instance, believes that the elevation of the mountains is due to immense force thrusting the eastern rocks up an inclined plane or reversed fault such as that described by Morgan in Westland.



Section across New Zealand, from Gillespies to mouth of Rangitata, showing gradual reduction in mountain heights from West to East. Vertical scale 1 in 2,000,000
Horizontal Scale 1 in 250,000

Influence of Mountains on the Distribution of Population.

The mountains of New Zealand have had a great effect upon the **distribution of population** and upon the industries that employ their energies.

In the South Island the Southern Alps interpose an effectual barrier between the lowlands on either coast. A single coach road connects them, and a railway now in process of formation will not be completed for many years. The Kaikoura Mountains separate as effectively the fertile plains of the Wairau from those of Canterbury.

The natural boundaries afforded by the mountain ranges were largely employed in the separation

of the provinces, and are still used as the boundaries of the land districts.

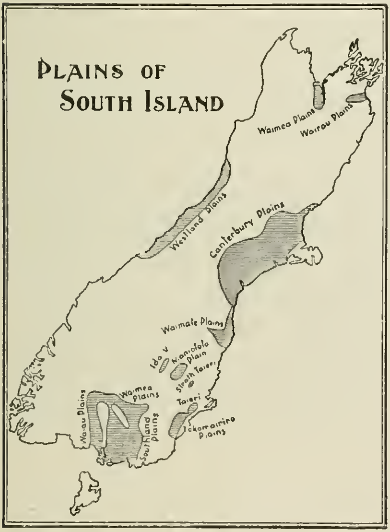
The mountain slopes and lower summits are in part clothed with a poor native pasture, especially on the eastern side, and are parcelled out into large sheep runs that support a sparse population of hardy shepherds and run-holders, whose homes are in the sheltered valleys. In many of the deep valleys gold is won from the river gravels, but the population dependent upon the industry is shifting and unsettled. In some of the larger valleys and basins in Otago the climate is perfectly suited for fruit-growing, but the want of railway connection across the intervening mountains has hitherto prevented the development of the industry and the close settlement of the basins.

The general effect of mountains upon the population and industry is similar in the North Island, but is far less marked, for the mountains are lower and narrower, and are almost everywhere covered with a dense forest growth, except where the winter snow lies too heavily on the slopes. The pastoral industry is therefore much less generally followed. The valleys have little or no auriferous gravels, so there is no mining population in the true mountain districts. The mountain valleys do not experience the peculiar climatic conditions that make the Otago Central district so suitable for fruitgrowing, so this industry also is not followed.

For these reasons the mountain districts of the North Island are almost destitute of a settled population except in those places where the lower slopes have been cleared of forest.

CHAPTER V.—PLAINS OF NEW ZEALAND.

The country has not been at a stationary level for a sufficiently long time for some geological periods to allow of the formation of extensive **peneplains.** The only small area that has the appearance of such a plain of river erosion extends from Pukerau to the Tapanui Mountains in Southland.



The whole of Central Otago is a rudimentary peneplain of great antiquity. The erosion of the rivers running through this elevated peneplain is reducing this area to another peneplain at a lower level. The old peneplain probably extended from the Mataura to the Waitaki and from Wakatipu to Dunedin, an area of 10,000 square miles.

There are no plains of **marine denudation** in New Zealand. The rock terraces raised a few feet above the sea level round the south coast of the North Island, from Cape Palliser to Terawhiti, mark the

commencement of the formation of such a plain. Elevation in this case took place before a flat area of any respectable dimensions was formed.

In many parts of the coast line where the sea margin is bordered by Cainozoic rocks, as at Shag Point in Otago, shallow water extends a long distance seaward. The bottom of this shallow water is flat, and is a plain of this type, though still

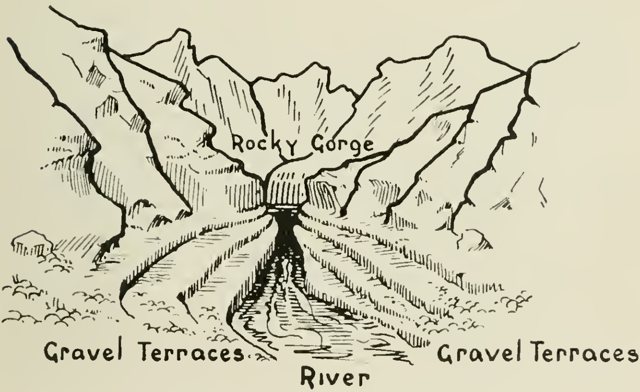
Plains near Gore, Southland. River Plains formed by the Mataura River.

submerged. The soft Cainozoic rocks are particularly prone to marine erosion, and the submarine plain is far more extensive on the Cainozoic coasts than elsewhere.

Plains formed by the deposition of **fluviatile** sediment have a much wider development. The **Southland Plains** extending from the south coast near Invercargill, to the **Waimea Plains** and the **Five Rivers Plains** are certainly formed in this way. Their surface is in parts stony, but where they are

too high for running water to wash over them, a deep rich soil exists.

The **Canterbury Plains** have a similar origin. The gravel of which they are composed has been derived from the steep mountain ranges of the west by the rivers that pass through them. Their level at the foot of the ranges is 1,000 feet or more above the sea level, and the surface slope to the sea shore is



A Canterbury River entering the Plains.

a very gradual one. The rivers that traverse the plains leave the lower ranges of the mountains through steep, narrow gorges. It is evident that when the upper parts of the plains were formed, the gorges were not so deep as at present, for now the gorge is continued into the gravels of the plains. The land has been elevated more than a thousand feet since the plains first began to form, and the rivers are still cutting their way downward, and they leave from time to time, on the soft and easily eroded

gravel banks, river terraces of small size but perfect form. In some of the gravel gorges eight or ten of these may be counted. The surface of the Canterbury Plains has fewer gravel patches, and a greater abundance of rich soil than those of Southland.

In Central Otago there are many isolated small plains filling basins in the schist rocks. The material of which they are formed has been laid down by the rivers that flow through them. The **Upper Taieri, Maniototo, Ida Valley,** and **Manuherikia** are the most important.

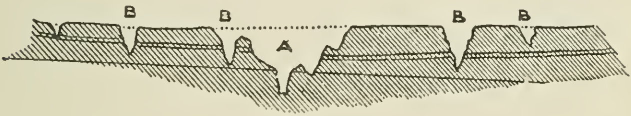
Plains of the North Island.

A similar plain to the Canterbury Plains extends as a narrow strip southwards from **Greymouth** almost to the Haast river. Large glacial moraines to some extent interfere with the level surface of the plain and in places form large bluffs on the sea shore. This plain is densely wooded.

In the North Island a plain similar in origin to the Canterbury Plains extends round the lower portion of the **Manawatu** River on the West Coast. Its surface is now cleared and laid down in grass,

but was originally very heavily timbered. The **Wairarapa Plain**, extending from Masterton to Palliser Bay, is another example, as well as the **Hawke's Bay** Plain.

The **Middle Waikato Basin** is a large flat area occupying the country between the Taupiri Range and the high volcanic country of the Mangatautari. It extends eastward to the Firth of Thames and westward to the Waipa. The plain consists of



Section of the Wanganui Coastal Plain. A. Gorge of Wanganui River. BB. Gorges of smaller tribntary streams. The dotted line shows the original surface of the plain.

pumice alluvium brought down by the Waikato River from the volcanic district of Lake Taupo. At its greatest distance from the sea, the plain has an elevation of no more than 100 feet. Its surface is often swampy, and in most parts there is very thin soil on the surface of the white pumice. In places it is well adapted for agricultural pursuits.

Plains of marine deposition.—The country lying between the Ruahine Mountains and Mount Egmont extending from the shores of the South Taranaki Bight to Mount Ruapehu is a typical plain of marine origin—a huge coastal plain. The elevation of its surface near Ruapehu is 2,000 feet above sea level, but it reaches to the sea level near Wanganui. The plain is intersected throughout its extent by deep streams and river gorges and valleys. In

places large flat areas form the watershed between adjacent rivers, but in other places the development of stream valleys in the soft Cainozoic rocks has reached such a stage that sharp ridges separate them. A traveller proceeding in a steamer along the Wanganui River gets the impression that the country is almost mountainous, as heights rise

Photo. Govt. Tourist Dept

Part of Volcanic Plateau, where Waikato River leaves Lake Taupo.

above him to 1,500 feet on either hand. When these heights are climbed, it is often found that a wide flat surface extends over their summit. This flat area is a portion of the original plain of deposition, which is now fast being despoiled, and the formation of a peneplain at a low level—the level of the river valleys—has been commenced. Its surface is densely wooded throughout. A similar plain exists

in some places on the east side of the Ruahine Mountains. In this region the horizontal surface of the rocks has been interfered with by the tilting of the rock formations and the consequent irregular surface has resulted.

The volcanic plateau.—This constitutes a large area of country extending north and west of Lake Taupo. It is known as the **Kaingaroa** and **Patetere Plains** in different portions. It is formed throughout of pumice—a light scoria ejected from some or all of the numerous surrounding volcanoes. In the pumice are often seen fragments of carbonised wood, though no old soils can be traced. The arrangement of the pumice has been effected to some extent by water, which also carried away the tree trunks scorched by volcanic fires. The surface of the plateau is fairly level, though in places intersected by deep but dry ravines. In the majority of these no water flows from year's end to year's end. They were carved out of the loose pumice by streams formed from the torrential rains that usually succeed or accompany eruptions.

The surface of the pumice is unproductive. It is covered naturally by a thin growth of bracken and manuka, and between the plants the loose pumice allows a foot to sink up to the ankle. This incoherence is the chief cause of the barrenness, for nearly all the rain that falls sinks at once through the pumice, and in the summer all the small quantity that remains in the soil is evaporated, and nearly complete desiccation lasts until the autumn rain falls. The area of the pumice is considerable, but in places, especially where small volcanoes rise

through it, and in some depressions, a luxuriant vegetation grows. The growth confirms the analytical results, which show that pumice contains in sufficient quantity all the chemical ingredients necessary for plant life.

The Plains and Population.—As in most countries, the greatest portion of the industrial population lives on the plains. The river plains of Canterbury and Southland are generally rich, for their surface is usually covered with a loam soil. Patches, some of them of a very large size are found, where gravel forms the surface, and there the population is thinner. A large population covers the richest portions of the plains, and towns of considerable size have sprung up on them. The produce is shipped from the few harbours that exist on the coast line, and at these harbours—Lyttelton, Timaru, Oamaru, and the Bluff,—larger towns have been built up. The first and last of these are merely ports, the distribution and collection of produce being performed at Christchurch and Invercargill, which are actually situated on the plains and act as centres of industry, to which the farming population of the plains resorts for supplies.

The Wairarapa, Hawke's Bay, Manawatu, Waikato, and Waimea Plains all support a considerable settled population engaged in agricultural and pastoral pursuits.

The Wanganui coastal plain is, in those portions of its area that are near the sea, also fertile and closely settled, but the more remote parts are rugged and still thickly covered with bush. When this

portion is cleared, it will be adapted for pasture and dairying occupations.

The volcanic plateau is barren. Few streams run on its surface. Native and European alike have refrained from forming settlements on its thirsty pumice soil. Until some means of consolidating the pumice have been found, only an extremely sparse population can settle there.

Chapter VI.—RIVERS OF NEW ZEALAND.

Work and Development of Rivers.—The Valleys and gorges in which rivers and streams flow, are formed slowly and gradually by the action of the river itself. The rain that trickles over the surface of the land gathers little particles of soil and sand. The removal of these leaves little channels in the soil, and as the particles are carried by the small streamlet against the stones and rock that form the sides and bottom of the channels, they knock off small particles from them, thus deepening the channel and undermining its sides. The sides fall in and the miniature landslip adds material to the tiny stream, for its loose matter is carried forward by the tumbling water. After a short independent course, the stream joins another—the united stream joins yet another until the gathered waters form the volume of a river.

Large or small, the action of the stream is always the same, always that of a file wearing away the bottom and undermining the sides. The deepening of the stream bed is spoken of as **corrosion**, and the

undermining and widening as **erosion.** Of these two actions corrosion is at first more active, but after a time the channel is worn so deep that the river runs but slowly down its very gradual slope to the sea. It is then unable to carry on the deepening process, for as much material is deposited by the slack current as is torn away by the impact of the sus-

Photo. Govt. Tourist Dept.

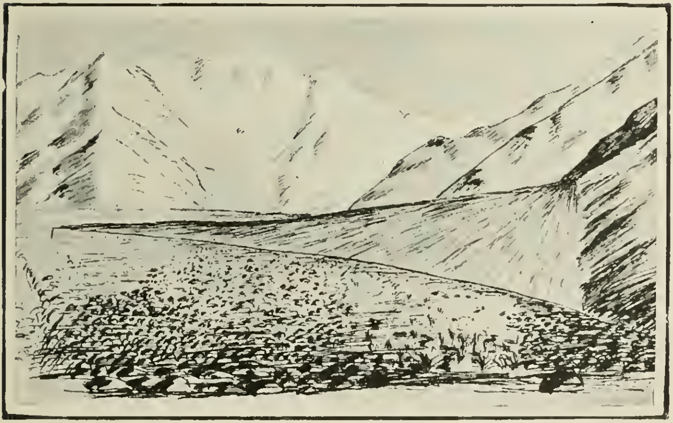
"Dress Circle," near Pipiriki.

A small tributary stream of the Wanganui. Here corrosion has formed a steep gorge that erosion has not widened.

pended particles of mud and sand. It is said to have reached its **base level.** Then the effect of the undermining action is more apparent, for it is now always performed at the same level, instead of being repeated again and again at successively lower levels. As the river swings from side to side of its valley, now against one projecting point, now

against another, they are one by one undermined and worn back, and a broad flat-bottomed valley is formed.

The impetuous hurry of the small side streams allows them to carry down much material that the slower main stream cannot remove. Thus are formed the long fans, or cones, of shingle that project far into many of our river beds.

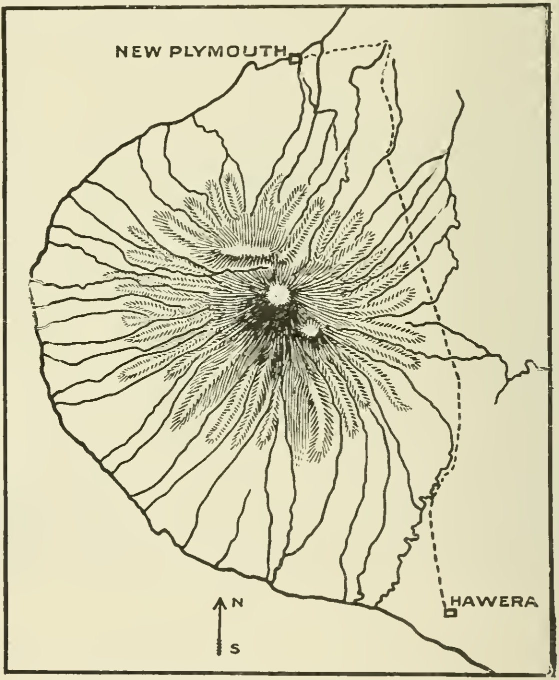


Cone of shingle deposited by a small stream in the flat river bed of the Rangitata.

The younger rivers must evidently have swift, turbulent streams and steep-sided gorges, while those of mature age flow steadily in open smiling valleys productive of the fruits of fertility.

But as they grow old, streams may interfere with one another. Imagine a gently sloping sea bottom elevated above the ocean waters. The rain that falls on it flows down its steepest slope towards the sea. Several roughly parallel streams are formed

whose course is a direct consequence of the slope of the ground. These are **consequent** streams. Suppose that one of these has its source in an area of heavy rainfall and traverses rocks particularly soft.



Consequent streams on Mount Egmont. They everywhere flow outward from the recently formed cone.

Its valley will be deeply cut and its tributaries will have a steep slope and work their way backwards from the main stream rapidly, especially if their channels follow a stratum of soft rock. They may even cut their way into the valley of the neighbouring consequent stream whose waters will flow down

the steep channel thus provided for it and join the first consequent. The formation of this channel evidently takes place after the consequent channels have been formed. It is, therefore, called a **subsequent** stream, and the consequent stream that has been robbed of its upper waters is said to be **beheaded.**

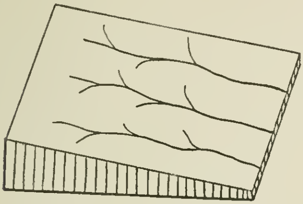


Diagram of a model of sloping land in which three consequent streams are formed.

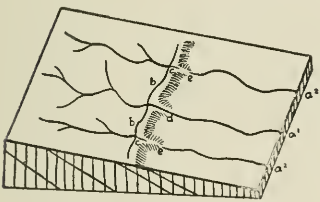


Diagram of same surface after interaction of streams.
*a*¹, Main stream.
*ea*², *ea*², Beheaded consequents.
bb. Subsequents.
cc. Obsequents.
ee. Air gaps } through escarpment.
d. Water gap

The subsequent stream continues to corrode its bed and before long a small stream flowing in the opposite direction to the beheaded consequent stream arises. This is an **obsequent** stream.

In many cases the rocks forming such a surface as that described are of unequal hardness, and the rock layers or strata are inclined. Then it often happens that the hard layers will be broken off steeply on the side from which they slope while on the other side the surface will follow the gradual slope of the inclined strata. Such a broken stratum is a **scarp** or escarpment. A stream passes through such a scarp in a gorge or **water gap,** for the hard rocks

are not so easily worn away as the softer rocks above and below them. The old water gap of a beheaded stream is an **air gap**.

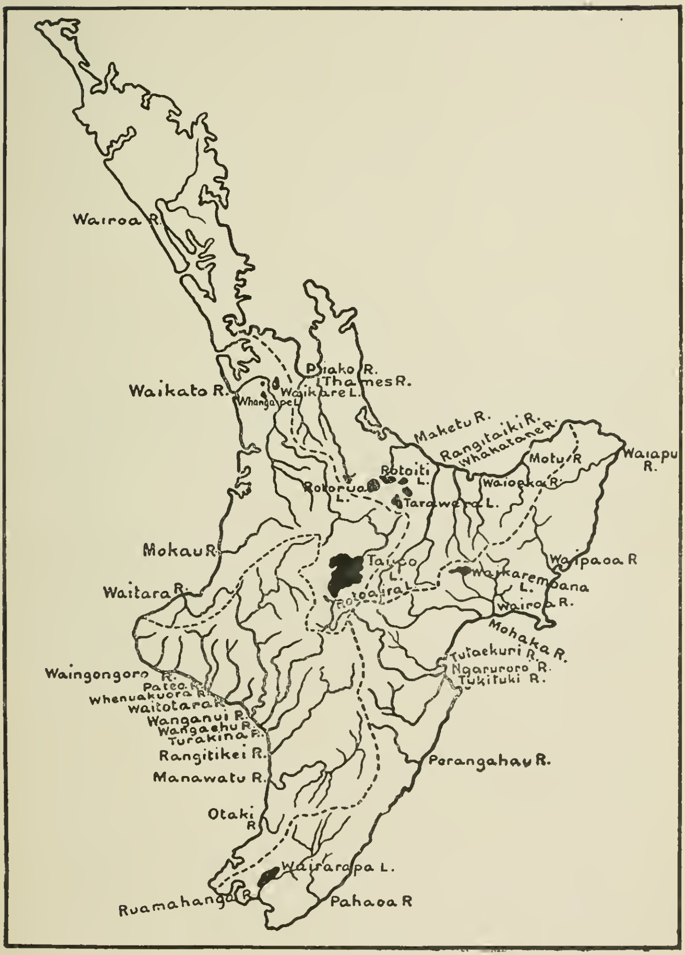
Rivers of the North Island.

Watershed.—The greater portion of the surface of the North Island of New Zealand lies to the north and west of the structural axis or backbone. A portion of this land is higher than any part of the great mountain range. It thus comes to pass that the divide between the two largest rivers—the Waikato and Wanganui—flowing respectively almost north and south, is nowhere coincident with the mountain range.

The first portion of this divide runs almost due east and west, then changes abruptly to north and south, a direction almost parallel to the general direction of the two rivers. Then turning rather sharply round the south of Mount Tongariro, the divide between the rivers, with a northerly and a southerly trend, runs slightly to the north of east, reaching the coast at the East Cape.

The divide in the southern part of the island leaves the one described above at the Kaimanawa Mountains, and passing for a time along the structural axis in the Ruahine Mountains, before long strikes to the east of it, and takes a line along the summit of the Puketoi Hills. It gains the structural axis again opposite the mouth of the Otaki River, and does not again leave it, but reaches the coast at Cape Terawhiti.

The northern portion of the island has a still more



Map of North Island Rivers.

eccentrically directed divide. It, too, leaves the east and west divide at the Kaimanawa Mountains, but is directed north-east until Tarawera Lake is almost reached. It then turns north-west, passing along the high country of the Maungatautari to the west of Lake Rotorua, and crossing the low-lying country of the middle Waikato basin, it strikes straight across the mountain range also, near Taupiri, and thence pursues a straight course to the Auckland isthmus. Thence it hugs the east coast closely, especially near Whangarei, where the basin of the Wairoa River penetrates far to the eastward. Its subsequent course offers no features of special interest.

In the extreme north the land is so narrow that no rivers of any magnitude have been developed. The close approach of the divide to the eastern coast decreases the area of the drainage basins of the east coast rivers to a minimum. The rivers of the west coast are of more respectable dimensions. They are all tidal rivers, and terminate in rias or in large estuaries, whose entrances have been partly blocked up by drifted sand. This fact proves that, since these rivers excavated their present channels, the land surface has been much depressed.

The **Hokianga** and **Wairoa** Rivers are the most important. The latter rises within five miles of the east coast, and empties itself in Kaipara Harbour, a broad, shallow expanse of water occupying a portion of the original lower basin of the river. It is navigable for fifty miles from the entrance to Kaipara, and the tide is felt for fifty miles further.

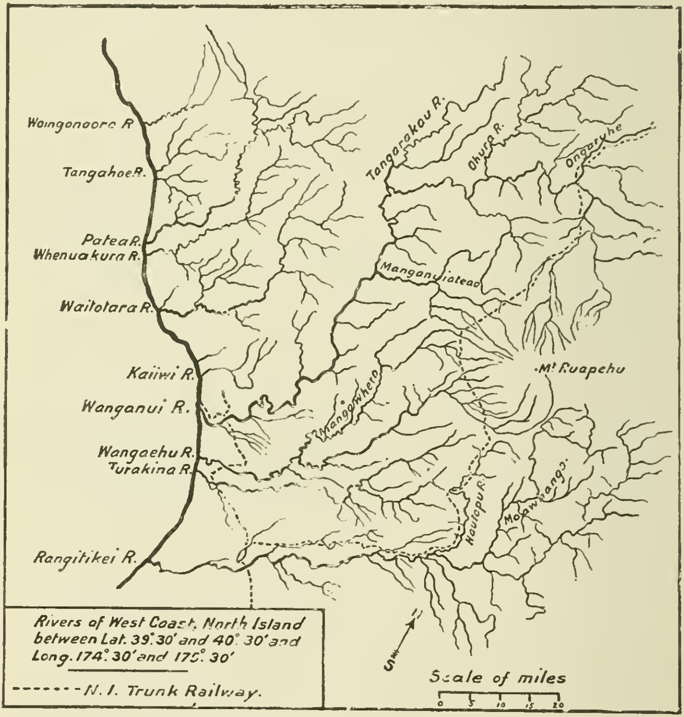
Thirty miles south of the entrance to the Manukau

Harbour the **Waikato** River enters the sea. Its total length is 270 miles. It rises on the eastern slopes of Ruapehu, just on the north-west side of the structural axis of the island. It flows into the southern end of Lake Taupo after a course of 40 miles. It issues from the northern end, and for some distance flows north-east until it is joined by the Waiotapu tributary. It then turns sharply to the

Port Waikato.

north-west, passing through the high volcanic country of the Maungatautari in a deep gorge. issuing thence, it flows across the flat plain of the middle Waikato basin, and passing through the range that bounds the basin on the north-west in the Taupiri Gorge, reaches the flat country of the lower Waikato basin. It turns west in the volcanic country near Pukekohe Hill, and becoming very shallow, finally enters the sea across a series of flat sandbanks.

The **Mokau** and **Waitara** flow westwards, and reach the ocean somewhat to the north-east of Mount Egmont. Both pass through country containing coal seams, and are navigable for vessels of light draught.



The navigation of all rivers on the west coast of New Zealand is much impeded by the presence of **sand bars** across their mouths. The sand is composed of the hardest and most resistant minerals of volcanic rocks, which have been worn to pieces by

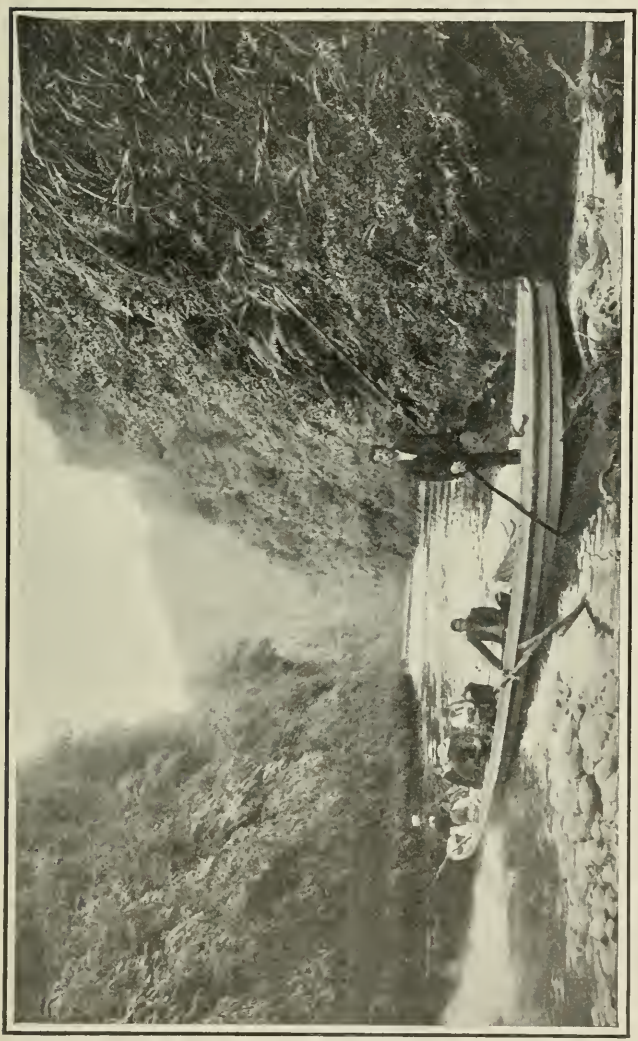
the rivers and ocean. The most abundant of them is magnetite—the magnetic oxide of iron—whence these sands have been called magnetic ironsands. The formation of the sand bars across the river mouths is a result of the combined action of heavy seas and of a sweeping oceanic current in a northerly direction. The heavy seas pile up the sand on the beach. and as some of the grains are momentarily suspended in every breaking wave, they are carried along the coast by the onward movement of the water with the current. The series of short steps takes them across the river mouths, where they form bars during their progress. and enables them in time to journey long distances along the coast line. The bars are temporarily displaced during floods; but heavy weather washing the sand along the coast soon completes their formation again.

South of Cape Egmont the rivers flow across the dissected coastal plain from Ruapehu to the Wanganui Bight. Their courses are, roughly, parallel from north-east to south-west. They all flow in deep, steep-sided gorges cut through the soft marls of which the coastal plain chiefly consists. The most important are the Patea. Whenuakura. Waitotara. Wanganui, Wangaehu. Turakina. and Rangitikei. The **Wanganui** is by far the largest. The main branch of the river rises on the north-west slope of Tongariro; but at Taumarunui. where the North Island Trunk Railway crosses it. it is joined by the Ongarulie, which rises to the north-west of Lake Taupo. The waters of its eastern tributaries are fed by the snow and rain that condense in large

quantities on the western slopes of the high volcanic mountains Tongariro, Ngauruhoe, and Ruapehu. The upper parts of these tributaries are generally mountain torrents flowing in rather shallow valleys over the alluvial plains round the mountain bases. When they enter the marl country, they flow in deep-cut gorges, often with vertical sides, which are also characteristic of the western tributaries as well as of the main river. The upper part of the Ongaruhe tributary drains the remnant of the old western mountain range.

The **Wangaehu** and its main tributary, the **Mangawhero,** drain part of the east and west of Ruapehu respectively. The actual source of the former is high up on the slopes of the mountain, close beneath the lake that now fills its dormant crater. The waters are densely charged with alum and sulphur, and, near its source, with sulphuretted hydrogen, but the last has all escaped into the atmosphere before the river has flowed many miles. The waters are at first milky-white, but the colour is lost as the water mingles with that of the numerous tributaries, though its nauseous taste still remains at the river's mouth. The Wangaehu and Waikato near their sources flow nearly parallel to one another as consequent streams down the slopes of Ruapehu.

After flowing thus for a few miles with less than half a mile of intervening land, they turn abruptly, the one north-east, the other south-west. The divide between them is almost level, swampy country, nearly 3,500 feet in altitude.



The Manganui-a-te-au: the largest tributary of the Wanganui, a typical gorge in the coastal plain.

The **Rangitikei** River rises in the Kaimanawa Mountains, and receives on its eastern side tributaries which carry to it the drainage from the greater part of the western slopes of the Ruahine Mountains. The western slopes of the tributaries have the usual streams of the steep-banked nature that course through the coastal plain. The upper parts of the main stream have the same features, but its lower course is over a wide gravelly bed formed by the deposition of the gravel supplied by its own tributaries.

The **Manawatu** River also in its lower course runs over gravel plains of its own making. Fifty miles from the sea it breaks through the gorge between the Tararua and Ruahine Mountains. Its waters are derived from the eastern slopes of the south portion of the Ruahine and north portion of the Tararua Mountains, and from the western slopes of the Puketoi Hills.

The only other river of importance in the Wellington Province is the **Ruamahanga**, which flows in a longitudinal valley between the Ruahines and the Maungaraki and other low mountains near the east coast. The **Pahaoa** and **Porangahau** are small streams flowing out on the east coast.

In the Hawke's Bay Province the **Tukituki** and **Ngaururoro** drain the east of the northern Ruahines, and Kaimanawas. Their upper tributaries lie in deep gorges of the mountain ranges, but before entering the sea they traverse alluvial plains of their own making.

The **Mohaka** and **Wairoa** rivers also flow into

Photo. Govt. Tourist Dept.

Te Huka Falls, near Lake Taupo, where the waters of the Waikato fall over a ledge of lava.

Hawke Bay. The former drains the north-east slopes of the Kaimanawa Mountains, and their continuation in the Ahimanawa Mountains. One of the largest tributaries of the Wairoa River issues from Lake Waikare Moana, but it has its sources, like the main stream, in the Huiarau Mountains.

The **Waipaoa** flows into Poverty Bay, having a general course almost north and south. With the Waiapu which flows almost north-east, it drains the south-eastern slopes of the Raukumara Mountains.

All of these rivers have mountain torrents for their sources, but their lower parts run in sinuous gorges through the marly formations that fringe the coast.

The large Bay of Plenty, in the Auckland Province, is entered by four rivers of some importance. The **Motu, Waioeka, Whakatane,** and **Rangitaiki** drain the north-eastern slopes of the Raukumara and Huiarau Mountains. The course of the first three of these lies in deep valleys penetrating into the recesses of the mountains. The main stream of the Rangitaiki traverses the pumice plateau of the North Island—the Kaingaroa Plains. It receives but few tributaries from the porous plains on the west, lying between the river and Lake Taupo, and further north, but its western tributaries are numerous and well fed by the heavy rains of the mountain districts.

The lakes of the Hot Springs region are drained by the unimportant streams **Tarawera** and **Maketu.**

The **Thames** and **Piako** enter the Firth of Thames. The former rises 10 miles to the west of Lake Rotorua, and flows along the western base of the Te Aroha Mountain, and its southern continuation. Its

main course is over nearly level country, and in the last sixty miles it falls less than 200 ft. The Piako also flows over low, flat, and swampy country. Its source is little more than 200 feet above the sea level.

The evolution or **development of the river system** described above cannot be considered without some reference to the main geographical changes in the later geological history of the North Island.

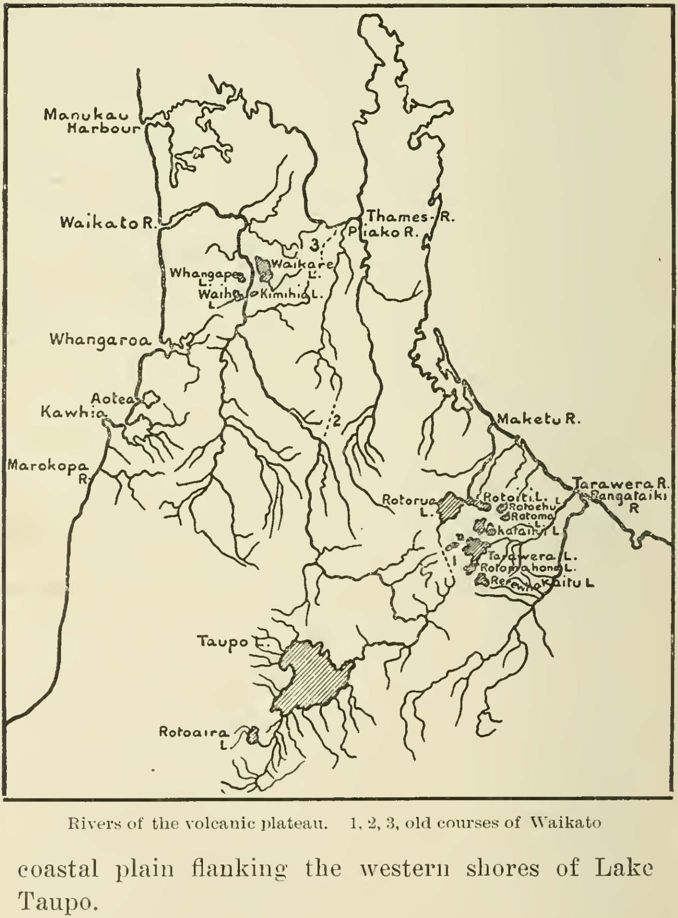
Up till comparatively late Cainozoic times the North Island apparently consisted of a long ridge of steep country extending along the direction of its present structural axis. This expanded somewhat in the Kaimanawa Mountains and East coast region, but was very narrow in the region of the present Ruahine Mountains. Other narrow steep islands lying more or less parallel to the main axis also existed. They are represented by the other older mountain ranges previously mentioned—the Raukumara, Mokau, Hakarimata, Coromandel, and some ridges in the northern peninsula near Whangarei.

These narrow islands were of considerable age, and river systems of a complicated nature had already been developed, especially in the broader parts of the Kaimanawa Mountains, where subsequent streams have in many cases beheaded the original consequent streams. In the narrow ridge of the Ruahine, the existence of consequent streams has been maintained, and the mountain streams here flow in parallel courses down the opposite mountain slopes.

Towards the close of the Cainozoic period, gradual slow elevation of the whole area took place. The elevation was accompanied by extensive and

prolonged volcanic activity in the central and northern districts.

This elevation raised the sea bottom into a wide



Rivers of the volcanic plateau. 1, 2, 3, old courses of Waikato

coastal plain flanking the western shores of Lake Taupo.

Volcanic eruptions had a still greater effect on the northern slopes of the high central volcanic country.

Here again, a series of consequent streams flow down from all the newly formed volcanic hills, but the eruptions in the volcanic plateau itself have completely obliterated any old drainage system that may have existed, and the recent date of the eruptions has not given time for the development of new valleys from which the interaction of the various consequent rivers and their tributaries could develop a mature system. The streams have, therefore, simply flowed along the lower country that separates one volcanic mass from another, and uniting with one another where low lying areas become confluent, have formed larger streams, and finally the larger rivers.

Mr. Cussen has traced several changes in the course of the **Waikato** River, which, since it flows through 200 miles of the volcanic area, has been more liable than the smaller streams to disturbances. He states that at first it flowed in a constant N.E. direction continuing lineally its course from Lake Taupo along the Waiotapu valley and across the present site of the Hot Lake region, entered the Bay of Plenty near the mouth of the present Tarawera River. Eruptions in the lake region blocked up this course, and the lake formed by the obstructed waters overflowed westward over the spurs of Motuwhara. A deep rocky gorge has since been excavated through the volcanic rock. On the north-western side of this gorge he thinks the river flowed in the present Hinuwera valley into the Piako River. By some cause at present obscure, the water was again ponded back and afterwards overflowed through some channel in the Maungatautari Mountains, through which another great gorge has been cut. The river then

entered the middle Waikato basin, which it partly filled with detritus. It appears to have left this basin in a stream entering the Firth of Thames, which then extended much further south. Afterwards it was intercepted by a stream flowing northwards from Drury, and it then took approximately its present course through the Lower Waikato Basin.

Whether the careful observations of Mr. Cussen are correct in every detail, or not, it is evident to the most casual observer that great changes have taken place from time to time. The alternation of deep rocky gorges with broad alluvial plains, penetrating far into the mountain valleys, proclaims loudly that obstructions of an important nature have, in many places, caused a complete change in the drainage valleys of the district.

The **Waipa**, the most important of the Waikato's tributaries, rises close to the headwaters of the Ongaruhe, the largest tributary of the Wanganui. Its course is peculiar amongst New Zealand rivers in one respect, for at Te Kuiti, 100 miles distant from the point where its waters mingled with those of the Waikato reach the ocean, its surface is only 160 feet above sea level, so its fall is only 1 ft. 7 in. per mile for that distance.

The Waipa receives the drainage from many of the hills of the volcanic region, and also the drainage on the east side of the range from Tuhua to Taupiri.

A striking difference from this Waikato basin is noticeable in the map (p. 134) showing the river system of the western plain sloping gradually outwards from the original islands that are now, since

the elevation, the mountain ranges. The rivers that had previously flowed directly from the steep island slopes into the sea had now to find their way over the gently sloping plains before reaching it. The gentle slope made them excavate meandering channels. As the country gradually rose, the

Manawatu Gorge.

channels were more deeply corroded, but still maintained their meandering course.

This gradual elevation would result in two regular river systems flowing nearly north and south respectively, as is actually seen in some perfection on the two sides of the north-east part of the country in the streams flowing from the Ahimanawa, Huiarau, and Raukumara Mountains.

In other parts of the island the development was

complicated by the formation of the high central volcanic country and the elevation of some of the rocks of the eastern coastal plain into the Puketoi Hills.

The formation of the high central volcanic country caused a new set of consequent streams to arise. A series of these flowed to the south. and entered the sea in the Wanganui Bight. (See map p. 134.)

The Wanganui River. whose tributaries were consequent streams flowing down the steep and rain-fed slopes of Mt. Ruapehu, was able to corrode its bed most rapidly, and one of its western tributaries worked its way backwards so fast as to truncate some of the more westerly consequent streams. This tributary became a subsequent stream. and extending itself further and further backwards. finally beheaded all the consequent streams as far north as the junction of the coastal plain and the central volcanic region. The highly porous and absorbent nature of the pumice soil effectually prevents the collection of surface water into small streams, while the impervious marly rocks of the coastal plain cause a large portion of the heavy rainfall to run off the land in surface streams. Hence the small streams and tributaries are far more numerous in the coastal plain than in the plateau. (Compare maps on pp. 134 and 142.)

The course of the **Manawatu**, which enters the sea in the southern portion of the Wanganui Bight, deserves especial notice. The river rises near the east coast in the Puketoi Hills and also disposes of

the rain that falls on the south-east side of the Ruahines, and the north-east side of the Tararuas. It then receives important tributaries from N.S. and E. After gathering these, it passes suddenly through a deep gorge in the mountain range, and flows thence to the coast over a gravel plain that it has formed for itself. The diversion of so much east slope drainage to the west coast is probably to be explained by the elevation of the rocks further east in the Puketoi Hills. This, for some time, prevented the corrosion of the eastern rivers from reaching so low a level as those on the west. The Manawatu in particular was able to extend its valley backwards so rapidly that it was in time able to intercept the drainage of the country affected by the eastern movements of elevation before a stable system of drainage to the east had been developed.

Mr. Hill, who has paid much attention to the surface features of this part of the country, believes that the basin of the Manawatu has always extended far to the east, and that the elevation of the Ruahines is a result of recent earth movements. He bases this belief on the occurrence of rocks derived from the volcanic area in the valley of the Manawatu to the east of the range. It would seem more probable that these rocks have some other origin, for the Ruahine Mountains form part of the structural axis of the island, and there is no independent evidence pointing to a recent elevation.

The rivers of the **Northern peninsula** are small and volcanic eruptions have considerably interfered with their development. It is, however, noticeable

that the fragments of the old mountain range lie near the east coast, and the rivers of the west coast have in consequence longer courses and are far more important than those on the east.

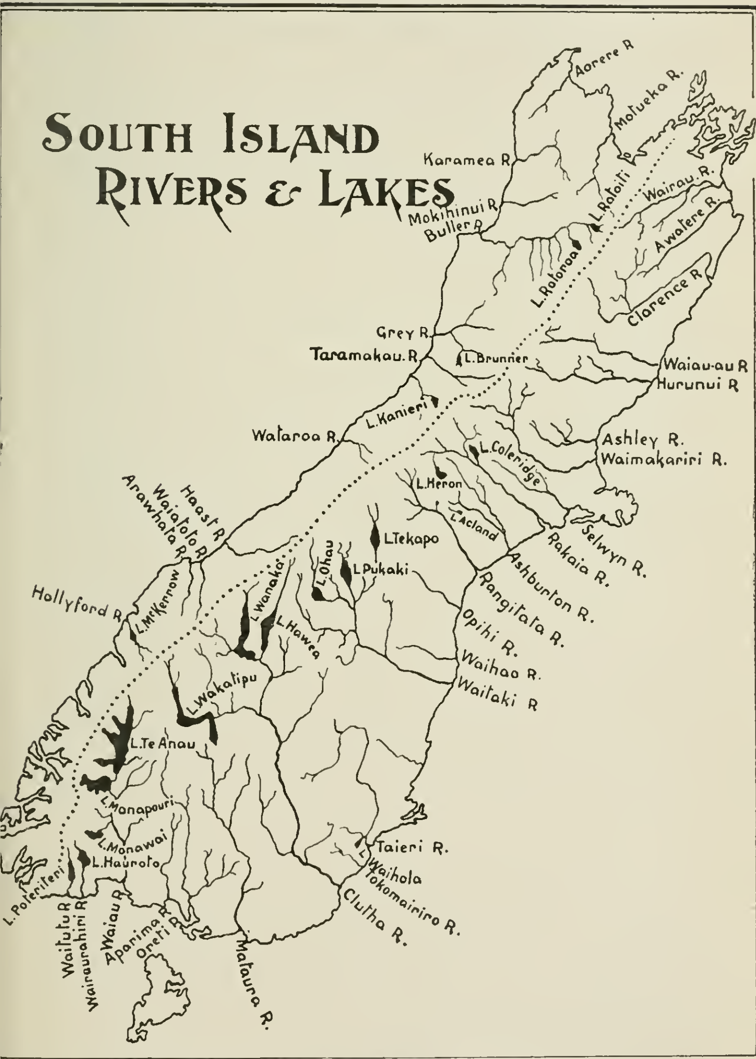
In all cases too, the rivers end in tidal estuaries, which often show a similar branching to that of rivers themselves. It is evident that they represent a submerged portion of the river valley.

South Island Rivers.

The main divide of the South Island is coincident with the main axis of elevation almost throughout its length, and this is also the structural axis of the land, or is perhaps slightly to the east of it, for the elevated country has suffered from various destructive agents on its western slopes to such an extent that the oceanic waves have partly advanced over the area which was perhaps the highest portion of the country when first it was elevated.

The main divide, as described above, separates the basins of the rivers flowing to the east coast from those flowing to the west. There are also two other, but much less important, divides, separating the basins of those rivers flowing into Cook Strait and those flowing into Foveaux Strait from the more ordinary river basins, which have courses directed almost due east or due west.

The rivers **flowing north** into Cook Strait are the **Awatere**, **Waiau**, **Pelorus**, **Motueka**, and **Takaka**. They all flow down steep slopes, for the most part, through mountainous country in deep precipitous valleys. Where the valleys widen out, the rivers


SOUTH ISLAND
RIVERS & LAKES
Aorere R
Motueka R.
Karamea R
Mokihinui R
Buller R
L. Rotoiti
Wairau. R.
Awatere R.
L. Rotoroa
Clarence R
Grey R.
Taramakau. R.
L. Brunner
Waiau-au R
Hurunui R
L. Kanieri
Wataroa R.
Ashley R.
Waimakariri R.
L. Coleridge
L. Heron
L. Acland
Selwyn R.
Rakaia R.
Haast R
Waiatoto R
Arawhata R.
L. Tekapo
L. Pukaki
L. Ohau
Ashburton R.
Rangitata R.
Hollyford R.
L. McKerrow
L. Wanaka
L. Hawea
Opihi R.
Waihao R.
Waitaki R
L. Wakatipu
L. Te Anau
L. Manapouri
L. Monawai
L. Hauroto
L. Poteriteri
Taieri R.
L. Waihola
Tokomairiro R.
Clutha R.
Waitutu R
Wairaurahiri R
Waiau R
Aparima R
Oreti R
Mataura R.

flow in meandering, ever-changing channels over the gravel plains that they themselves have formed.

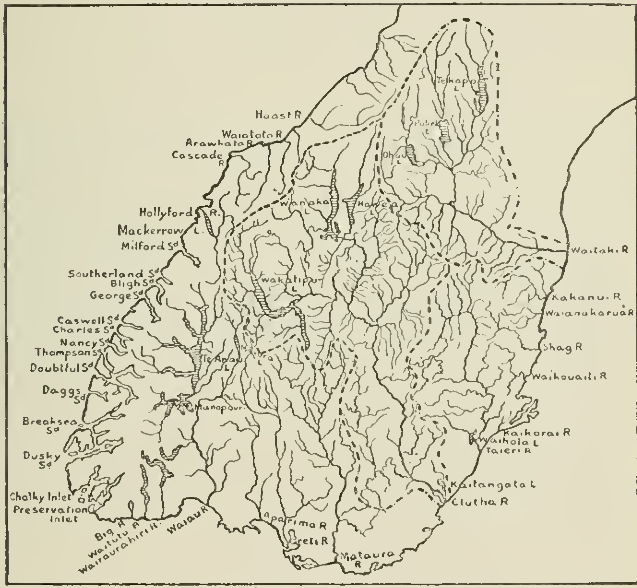
The rivers flowing to the **west coast** have very steep beds. For the most part they are short, as the main divide lies so close to the coast. In the northern portion, where the axis is at some distance from the coast, the rivers have a much greater length, and form important streams. To the north of Cape Foulwind the **Karamea**, **Mokihinui**, and **Buller** are the largest. The latter is the most important. Rising in a high, mountainous district, it crosses some level plains, and finally enters the sea through a steep, narrow gorge.

South of Cape Foulwind, the **Grey**, **Taramakau**, **Hokitika**, **Karangarua**, and **Haast** are the longest. All of these, except the Grey, are torrential streams, most of them having glacier sources in the most elevated portions of the Southern Alps. They flow in deep gorges in their upper portions, and in their lower course over the narrow, gravel, coastal plain that separates the mountains from the sea. They are all liable to sudden and violent floods, especially when a warm spring rain from the north-west falls on the snow and ice that accumulates during the winter.

The rivers in the West Coast **Sound district** are all unimportant. They take their rise in high mountain valleys, and flow in deep, narrow, but flat-bottomed gorges, with precipitous sides to the heads of the fiords, which are merely continuations of the stream valleys.

Foveaux Straits are entered by four important

rivers—the **Waiau, Aparima, Oreti,** and **Mataura,** all of which rise in the mountain districts of Central Otago. Their valleys are at first mountain gorges, narrow and deep, but near the coast they flow over wide plains in channels that wander to and fro over their gravel beds. The Mataura, six miles south of



River system of south part of South Island. The dotted lines enclose the drainage areas of the Clutha and of the Waitaki.

Gore, has worked its way to the west border of the hilly country of the south-east of Otago. The rocks are composed of strata of unequal hardness. and at Mataura the river falls in a cascade over a stratum of greywacke of more than average hardness. This is the only instance in New Zealand of any of the large rivers falling over a waterfall near its mouth.

The **Clutha** is the southernmost and the largest of the important **east coast** rivers. The main river and its largest tributary issue from lakes that lie imbedded in the wild alpine region close to the watershed and structural axis of the South Island. The main stream flows now in a deep gorge, now across a broad level plain, but at all times the velocity of its current is great, and the quantity of water that flows in it is greater than that of any

Upper part of Rangitata Valley, steep sided but with broad flat bottom.

other New Zealand river. It is renowned above all New Zealand rivers for the quantity of gold contained in the gravel and on the bed rock over which it flows. The gold is derived from the schist rock of which all this country is formed. The rock carries little gold; but the heavy nature of the metal has caused it always to sink to the bottom of the river when released from its parent rock by the gradual wearing action of the water. This process

continuing throughout geological ages, has resulted in the accumulation of rich pockets wherever any obstruction in the river's course has temporarily reduced the stream's velocity and allowed the heavy metal to sink down more readily. The variable nature of the banks of the Clutha, from precipitous gorges in the mountains to low banks in the more level plains between the mountain ranges, clearly indicates a complicated development which will be detailed later.

The area of the watershed of the Clutha is shown in the map on p. 151, and it is clearly seen to be a much wider area than that of the other large east coast river, the Waitaki.

The **Taieri** and **Shag** Rivers are the two most important rivers of Northern Otago.

In Canterbury, the **Waitaki**, which forms part of the border between Canterbury and Otago, the **Rangitata**, **Ashburton**, **Rakaia**, **Selwyn**, **Waimakariri**, and **Ashley** are all rather similar in their nature. They flow through steep-sided, but broad, mountain valleys in their upper parts, then issue through the eastern mountains in narrow, steep-sided gorges, and cross the coastal plains in wide, gravelly river beds, in which the actual channels are notoriously inconstant. The reason for the sudden change from the broad upper valleys to the narrow lower gorges is probably to be found in an elevation of the eastern portion of the range by slow earth movements, or in the over-deepening of the upper portion of the valleys by glacial action, and the subsequent infilling by river gravels.

The more northerly of the east coast rivers—the

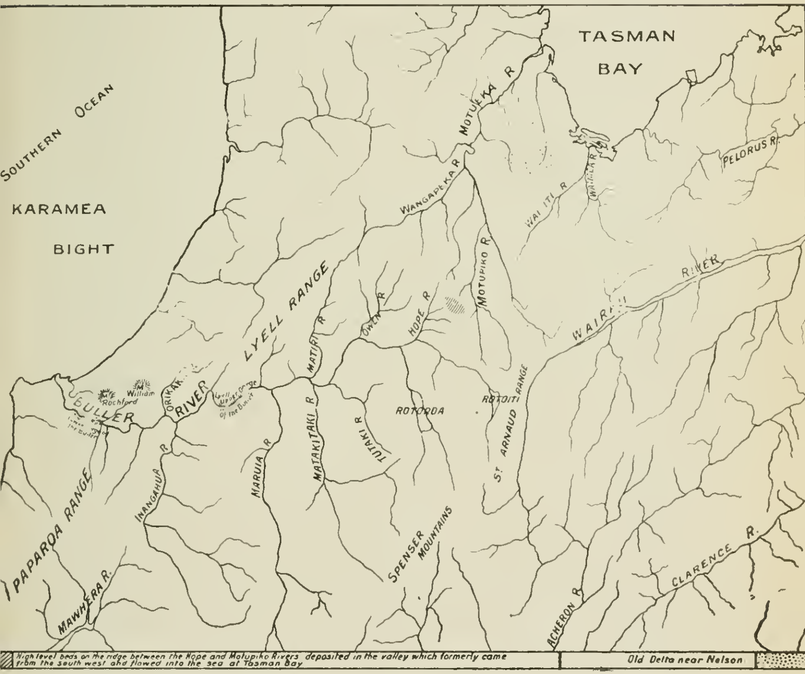
Hurunui, Waiau, Clarence—have characters rather similar to the last; but the gorge region is not so well marked, and the over-deepening of the upper valleys less pronounced.

Development of River System.

The rivers of the South Island have undergone a more prolonged development than those of the north. The country being for the most part of a high elevation, the rivers are rapid, and have greater corrosive power. This has enabled them to lower their beds to a profound depth since the interactions between the various streams took place. Complications have arisen as results of the partial or complete filling up of the channels earlier eroded during the Cainozoic era. Glacial erosion and deposition has changed completely the form of many valleys, and caused a reversal of flow, or has diverted the course of the water in others. Finally, earth movements appear to have influenced the process of valley formation in some districts.

In north-east Nelson and Marlborough the parallel valleys of the **Wairau, Awatere,** and **Clarence,** and its tributary the **Acheron,** at once attract attention. The towering mountain ranges on each side of these valleys are of Maitai formation; but, in the bottom of the valleys, Cainozoic and volcanic rocks are found. According to Sir J. Hector and Mr. Mackay, who have carefully examined these localities, the valleys are not the result of river corrosion, but of huge crust fractures and earth movements as previously described. The gorge of the Clarence, between the Inland and Sea-

ward Kaikoura Mountains, is one of the most profound and precipitous in New Zealand. It is believed by the geologists mentioned above that the earth movements which have formed it are still in progress.



Map showing present courses of Buller and Motueka rivers.

The **Pelorus** River and others entering the Pelorus and Queen Charlotte Sounds now retain only their upper portion. They have been betrunked by the submergence of their lower courses.

The lower course of the **Motueka** is along the

border between the granite ranges and a huge gravel formation of late Cainozoic age. There is reason for thinking that at one time its head waters reached further south, and that accumulations of glacial moraines have helped the Buller River to capture some of the original tributaries of the Motueka.

The **Buller River** is one that has seen more changes than the majority of New Zealand rivers. The channels in which its head waters run have been worked out for a long period, for nearly all of them are partly filled with Cainozoic deposits. It is probable, as before stated, that some of these belonged previously to the Motueka River, and have only lately been acquired by the Buller.

The old course of the Buller, in the lower portion of its flow, originally lay through the valley now drained by the Inangahua and Mawhera, tributaries of the Buller and Grey respectively. This course was much longer than the one now followed through the Buller Gorge from Reefton to Westport. The change occurred after a depression in the Cainozoic age. It was evidently the result of the activity of a consequent stream flowing down the coast ranges. Flowing in a short and steep channel, this stream corroded its bed far more rapidly than the much longer Grey River, and when the latter was intercepted, its upper waters flowed down the new channel. Thus the present **Grey** River is a beheaded remnant of the larger ancient stream. The low saddle between the upper Mawhera and Inangahua is an "air-gap." The Inangahua is an obsequent,

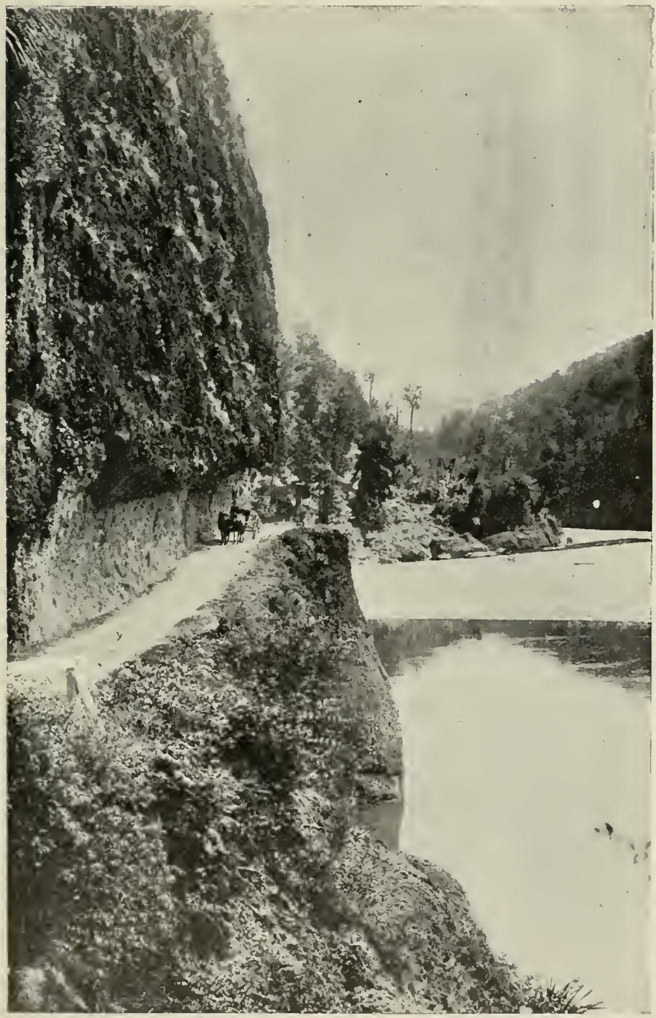


Photo. Govt Tourist Dept.

Gorge of Buller River.

the lower Buller a subsequent, and the gorge itself a water gap.

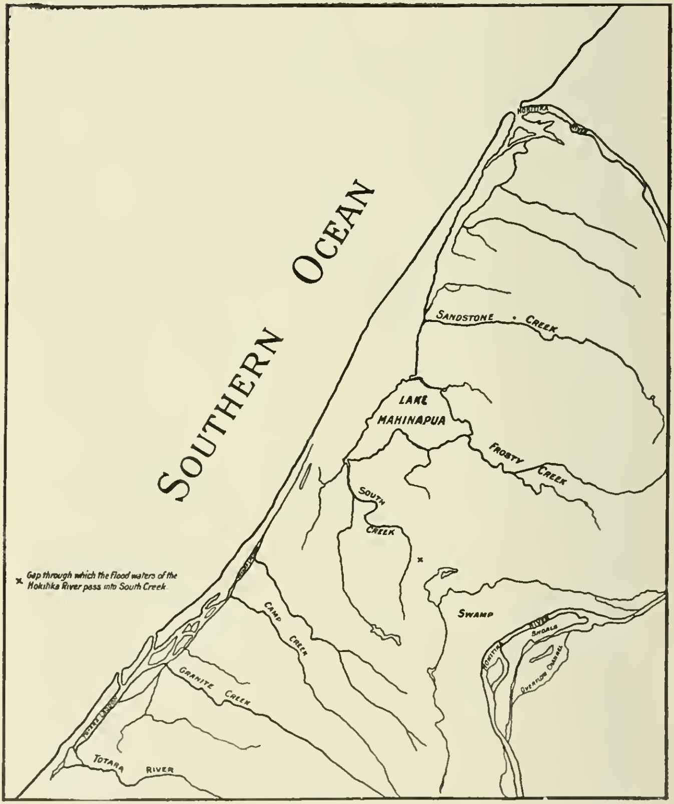
The rivers of the **West Coast** of the South Island have comparatively short but steep courses. They rise near the summit of the ranges, often, especially in the more southern portions, in glaciers. In their upper portions they pass through profound mountain valleys and gorges and, issuing from them, flow across the narrow coastal plains in wide river beds. On the coast, where the river current is stopped by the ocean, the shingle these rivers carry is heaped up into long gravel banks (p. 160). Through these banks the actual outlet of many of the smaller streams is ever changing. In many cases they may be closed for months by a heavy gale, and they are not cleared until a heavy flood occurs.

The **Haast** and the **Hollyford** are to some extent exceptions, for both drain longitudinal valleys, and both penetrate through the highest ridges in the mountain area. Low passes separate the valleys of both rivers in more than one place from the drainage basin on the opposite side of the range. The Greenstone Pass between the Hollyford and the Lake Wakatipu basin is only 2,000 feet.

In the **sounds region** hanging valleys are very abundant. These are valleys that in their upper portions are well developed and have the usual shape, but are abruptly truncated at some few miles from this source, and their streams fall over vertical precipices into a main valley that truncates them. Bowen Falls (see p. 159) and Stirling Fall in Milford Sound are excellent examples. The former

Bowen Falls, Milford Sound: 530 feet.

is 530 feet in height and the latter 510 feet, while the water of Milford Sound into which it falls is



Shows deflection of mouth of Totara River and of South, Frosty, and Sandstone Creeks by bars.

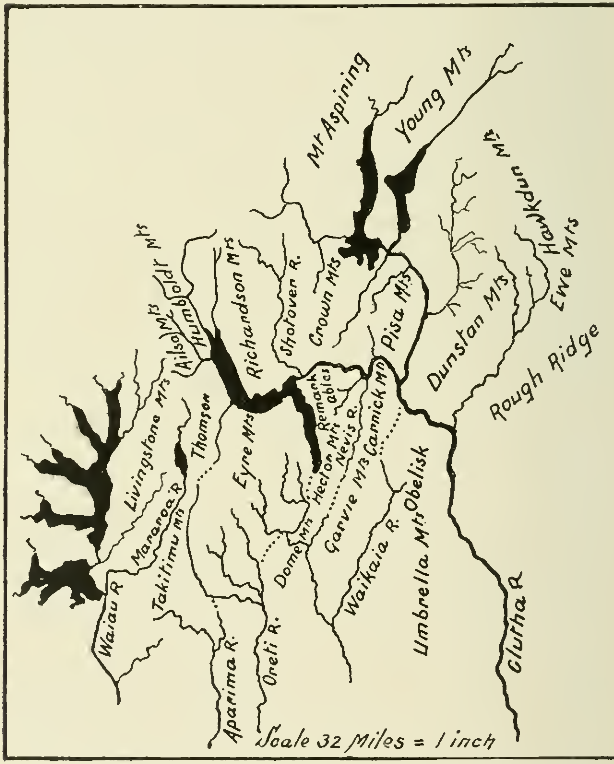
600 feet deep, so the total height of the precipice that truncates this valley is 1100 feet. The Sutherland Falls (see page 4) on the Arthur River affords

another example. The water from the valley above here falls over a precipice 1904 feet in height.

The cause to which the formation of **hanging valleys** is due is disputed. There is no doubt that in some way the deepening of the main valley has been rapid, while that of the hanging valley almost ceased. By some the rapid corrosion is ascribed to the cutting off or beheading of one stream by another, an action that is followed by a great increase in rapidity of wearing rate in the main stream owing to the provision of a shorter and steeper channel, while the tributary is but little affected. By others it is supposed to be due to the protecting action of a snow covering on the higher tributary valleys, while in the main deep valley the water still corrodes its bed. Others explain it as the effect of a large thick glacier corroding the main valley, while the thinner ice of the lateral valleys have little corroding power. This last explanation is supported by the frequent occurrence of the hanging valleys in regions where there are other independent proofs of heavy glaciation and by their comparative absence elsewhere. This is particularly noticeable in New Zealand, for hanging valleys are absent in the northern mountain regions which have never been glaciated, while in the south they are abundant and are most numerous in the districts where glaciation has been most severe.

The courses of the rivers on the West Coast are so little known that no attempt can here be made to trace the development of the river system. The

general east and west course of the streams, that is, outward from the main axis of the mountain system, suggests that they are consequent streams



Present arrangement of rivers and mountain ranges in Otago.
Dotted lines show a probable earlier river connection.

that have undergone little modification or development.

The rivers flowing into **Foxeaux Strait** need no

especial mention, though some changes have taken place under the influence of climatic variations. Thus, the **Mararoa**, one of the largest tributaries of the Waiau, formerly rose at the Greenstone Saddle. The upper fifteen miles of the valley was afterwards filled by a glacier that left morainic accumulations at the Mavora Saddle. The lake formed behind this dam was drained by a consequent stream that worked its way back from Lake Wakatipu, and the water now flows down the bed of this stream through the Greenstone Gorge into Lake Wakatipu.

The development of the **east coast** rivers cannot be fully described here, for the rivers are numerous and the changes they have undergone are many.

In the south the **Mataura** and Clutha are particularly interesting. The former rises in the Eyre Mountains south of Lake Wakatipu (see maps pp. 102, 162). Its head waters cross transversely the nearly level surface of the Lake Wakatipu moraine and enter a profound gorge on the eastern side through the Dome Range, joining on the eastern side of this range with the Nokomai, whose valley is a direct continuation of the Nevis tributary of the Clutha. The original direction followed by the river flowing from the ice that filled Lake Wakatipu was south, following in all probability the present course of the Oreti River. As afterwards explained, the overflow from the lake that succeeded the glacier was directed to the Kawarau Gorge. At this time the upper Mataura must have been a feeder of the lake entering it at the southern end. This was afterwards cut off by a tributary of the Nokomai that worked its way back across the Dome

Range. It is probable that the Nokomai, formerly extended up the present Nevis valley and even across the present Clutha valley.

The development of the valley of the **Clutha** River is one that offers many problems of great interest. Almost the whole of its drainage basin is formed of schist rocks perhaps of the greatest antiquity. It is traversed by mountain ranges of an elevation usually between four and six thousand feet. It has been previously stated that the direction of the mountain ridges runs nearly due north and south. The general course of the Clutha is south-east. In its course it cuts across three of the mountain ranges. As explained before, this country is the crest of a mountain structure whose axis is directed south-east and emerges at Dunedin. It is, therefore, evident that the Clutha course is in a general sense parallel to the structural mountain axis and the mountain ranges run transversely to it. This curious arrangement of the natural features evidently demands some special explanation.

The whole of the drainage basin of this river has been described as a peneplain of great antiquity. After it had been eroded to the form of a peneplain, the whole of the area was elevated and consequent rivers flowed down its sides. These rivers corroded deep channels, and finally the peneplain was dissected into a series of main ridges running north and south separating the channels of the consequent streams. From the relative direction of the mountain ridges and of the rivers, it appears that the Clutha originally ran between the Rough Ridge, Hawkdun and Ewe Mountains on the one side, and

the Umbrella, Obelisk, and Dunstan Mountains on the other or western side.

The **Waikaia** ran on the western side of the last named and on the eastern side of the Garvie, Carrick, Pisa, M'Kerrow, and Young Mountains.

Scale: 1 inch = 16 miles.
Map showing change of river channels of South Canterbury. Old river valleys marked thus - - - - now filled with moraine.

The **Mataura** flowed on the western side of these mountains and on the west of its channel were the Dome Mountains, Hector, Remarkable, Crown and its continuation to Mt. Aspiring. The **Oreti** River

following the present course of the upper Mataura, the **south arm** of **Lake Wakatipu** and the **Shotover** flowed on the west side of the last named streams. It drained the eastern slopes of the Eyre, and Richardson Mountains.

The **Aparima River** following the present course of the Upper Oreti, Von, northern arm of Lake Wakatipu, and Dart drained the west slopes of the ranges just mentioned, and the east slopes of the Thomson and Ailsa Mountains.

The **Mararoa** flowed on the west of these. It drained the east slopes of the Takitimu and Livingstone Mountains. Lastly the **Waiau** flowed still further west, receiving the western drainage of the south portion of the Alps.

The causes of the enormous **changes** that have occurred **in the drainage** of the province since it was developed, along the lines given above are chiefly those resulting from the continuous development and interaction of streams. The blocking up of pre-existing valleys by moraines during the period of maximum glacial advance has also had much influence on the diversion of the stream channels. A complete account of the causes and stages of development of these streams cannot here be given. It will be sufficient to trace some of the more important of these in connection with the Clutha river (see p. 162).

The upper portion of the Waikaia was cut off by the active corrosion of a tributary stream of the Clutha joining it from the west. The intersected waters flowed down this, and the Dunstan Gorge was formed. That large streams actually passed

into the head waters of the Waikaia is clearly shown by the existence of auriferous gravels at as high a level as 4000 feet. The gorge between the Pisa and Carrick ranges was formed in a similar manner, and the head waters of the Mataura entered the Clutha. Finally the huge moraine deposited in the Oreti Valley, whose upper portion was occupied by the Wakatipu glacier, caused a large ponding back of the waters of that river. It drained away through the gorge that had been previously cut by the waters of the Shotover and Arrow when they were ponded back by the Wakatipu ice, which extended to a height of 1500 feet above the present lake level at Queenstown. The middle portion of Lake Wakatipu had been previously formed by a tributary of the old Oreti that had cut down a valley which intercepted the upper waters of the Aparima River.

Thus the present Clutha River is composed of the head waters of Waikaia, Mataura, Oreti, and Aparima Rivers, and its course runs parallel to and not far from the crest of the main structural axis of Otago.

The Canterbury Rivers are almost entirely consequent streams flowing directly outward from the main axis. They are similar in their character to those of the west coast, and except possibly in the case of the Waitaki, no interferences on the major scale have taken place between them. Glacial moraines forming dams in some of the valleys have, however, made some noteworthy changes, and have even reversed the direction of some streams. Thus the head-waters of the present Rakaia originally

flowed down the valley in which Lake Heron lies. and joining the South Ashburton, flowed through Puddingstone valley into the Rangitata. The moraines deposited during the greatest glacial advance completely blocked the outlet by the Puddingstone valley, and the water then went down the Ashburton gorge following a subsequent course corroded by one of the Ashburton tributaries. Afterwards during a temporary halt in the glacial recession, the Hakatere valley was blocked by moraines at Lake Heron, and the water flowed down the present Rakaia bed which was cut down by a tributary of the Mathias.

Many of the valleys of the Canterbury rivers are of great antiquity; for they had been well developed in the earlier Cainozoic. They were afterwards partly filled up by Cainozoic limestones and have been again excavated.

Influence of the Rivers on the Distribution of Population.

The influence of the New Zealand rivers on the **distribution of population** has been comparatively small, since the settlement of the country by Europeans. None of the rivers are navigable for more than a very few miles from their mouth. It is true that on the Wanganui River small flat-bottomed river steamers can ply to a distance of a hundred miles from the sea, but the capacity of these steamers for cargo is exceedingly small, and conveyance is relatively expensive. In a few instances there are towns of importance at the mouths of the rivers, but their trade is to some

extent precarious, for the bars that extend across the mouths are not always navigable in rough weather. The most important of the river ports are Greymouth, Westport, Wanganui, Waitara, and Thames. The New Zealand rivers have not as a rule deposited wide fertile alluvial plains, so there is seldom any settlement along their banks. The Waikato is to some extent an exception, for on its banks are Drury, Ngaruawahia, Hamilton, and Cambridge.

The river valleys in many instances afford opportunity for easy lines of roadway to the broader and more fertile districts beyond the hills or mountains that the rivers pass through. The Manawatu Gorge is the natural line for road and railway between the Hawke's Bay and West Coast areas.

The Wanganui River is much visited because of the beautiful rugged bush scenery on its banks. The visitors stay at Pipiriki, which is becoming an important settlement.

Chapter VII.—GLACIERS.

Formation.—The snow that falls on the higher slopes of mountain ridges is not melted in the summer months. By pressure and partial melting it becomes compacted into solid ice. This behaves as an extremely thick or viscous fluid, and gradually flows down into the valleys. A glacier flows more rapidly in the middle than at the sides and more rapidly at the bottom than at the top. Its flow is continued along the valleys until it reaches a level

where the rate of melting is more rapid than the rate of supply of ice. At this level the glacier, as the ice stream is called, is replaced by a river which is formed of the water supplied by the melting ice.

On the more precipitous slopes of the mountains the flow of ice to the valleys is not gradual. From time to time the weight of masses of ice causes them to break away from the portion behind, and they

Heaps of glacial moraine in Tasman valley. Mount Cook in background.

fall as huge avalanches or ice slips into the valley. The avalanches carry with them rocks and stones that they tear from the mountain sides. These accumulate on the sides of the glacier, and form **lateral moraines**, which are carried on the surface of the ice as it slowly marches on.

Where a side valley joins the main one, the two lateral moraines unite and form a **medial moraine**,

which may extend as a line of rock fragments down the centre of the glacier. In the upper portions of a glacier more snow falls every year than melts, so the moraines are covered with congealed snow or ice, and the unsullied ice surface extends from side to side of the glacier valley.

Functions.—In the lower portion of the glacier course, where the surface melts more rapidly than it is replaced by fresh snow, all the moraine fragments become visible, and the ice may be completely covered by moraine.

Since ice behaves as an extremely thick fluid, it cannot yield rapidly to inequalities or sudden change of slope of the valley in which the glacier flows. This want of plasticity or bending power of the ice causes huge gaping fissures to arise. These are the **crevasses** which sometimes extend for hundreds of feet into the ice.

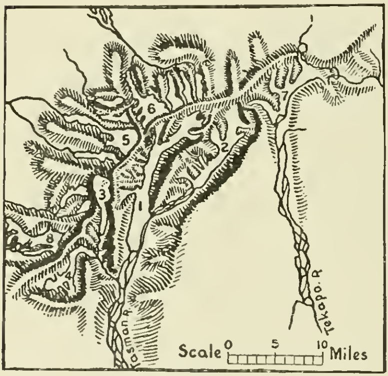
The ice on the surface of a glacier is constantly melting in summer, and small rivers are formed on the glacier. They plunge into the deep crevasses over waterfalls, and carry with them some of the moraine on the surface. These rocks and stones finally reach the bottom of the ice, where, frozen into it, they are forced over the glacier's bed, and scratch and polish the rocks on its surface. The fine powder formed is carried along by the water flowing beneath the glacier, which finally issues as a turbid stream from the terminal face of the ice.

The corrosion of a glacier will evidently be most rapid where the ice is thickest, and therefore heaviest. This is generally just below the middle of the glacier. The glacial valley would therefore

be deepest here, and shallow rather rapidly towards the lower end. The valley would become an elongated basin but U-shaped in cross sections.

It is by this action that the glacier deepens its valley, and its rapidity and importance have been the subject of much dispute by those who study the effects of glacial erosion.

The snowfields on mountains which form the feeding ground for a glacier are termed the **nevé.** As the ice of the nevé flows down to the glacial valley, huge fissures arise in it. These have one side or lip higher than the other. They are called **berg schrunds. Seracs** are pinnacles of ice formed in a glacier that is much broken up by crevasses.



Map of Mount Cook Glaciers.

1. Tasman.
2. Murchison.
3. Hooker.
4. Mueller.
5. Fox.
6. Franz Josef.
7. Godley.
8. Douglas.

Glaciers of New Zealand.—It is evident from what has been said that the source of supply of the ice of glaciers must lie above the snow line. Consequently, glaciers can be formed only in these districts where there is a large area of country possessing a great elevation.

In the **North Island,** the snow level is at an

elevation of between 7,000 and 8,000 feet, and there is only one mountain that possesses any considerable area above this level. Ruapehu alone, of the North Island mountains, has glaciers on its flanks. They are small hanging or secondary glaciers, that is, they fill small depressions or valleys on the steep mountain slopes.

Tasman Glacier. Mount de la Bêche in the background,

In the **South Island** glaciers attain a great development. Throughout the extent of the Southern Alps mountain peaks rise here and there so high that hanging glaciers are formed in the upper part of the valleys that cut into them.

In the central part of the chain, in south-west Canterbury, the mountain ranges for some distance average a height of 9,000 feet. Situated, as this portion is, close to the Tasman Sea, from which the prevailing moist winds blow, the amount of con-

densed water vapour falling as snow on the mountains is especially great. All the small valleys on the mountain slopes are filled with ice, and it constantly flows from these to the main deep valleys in which trunk glaciers are formed. Avalanches of snow, rocks, and ice constantly thunder down the steep mountain slopes on to the ice surface below.

Trunk glaciers flow in the main valleys on both the west and east side of the mountain ridge. The characters of the glaciers on the west side differ markedly in some respects from those on the east. The precipitation of snow is heavier, and the slope of the mountain range much steeper on the west. The glaciers therefore flow more rapidly, are much rougher, and more crevassed, and reach to a lower level on the west side.

On the eastern slopes are the Tasman, Murchison, Godley, Mueller, and Hooker Glaciers. They are all in the immediate neighbourhood of Mount Cook with the exception of the Godley Glacier, which is rather further north. The ice from Mount Cook itself flows on the north-east side to the Tasman, and on the south-west side to the Hooker Glacier. All these glaciers, except the Godley, are easily accessible from the Hermitage, a small hostelry maintained by the Government.

The great **Tasman** Glacier is 18 miles long—one of the largest of all glaciers in temperate regions. It rises in the Hochstetter Dome. On the eastern side it receives the ice from Mount Darwin and Malte Brun, and on the western that from Elie de Beaumont, the Minarets, Mount Green, Mount De

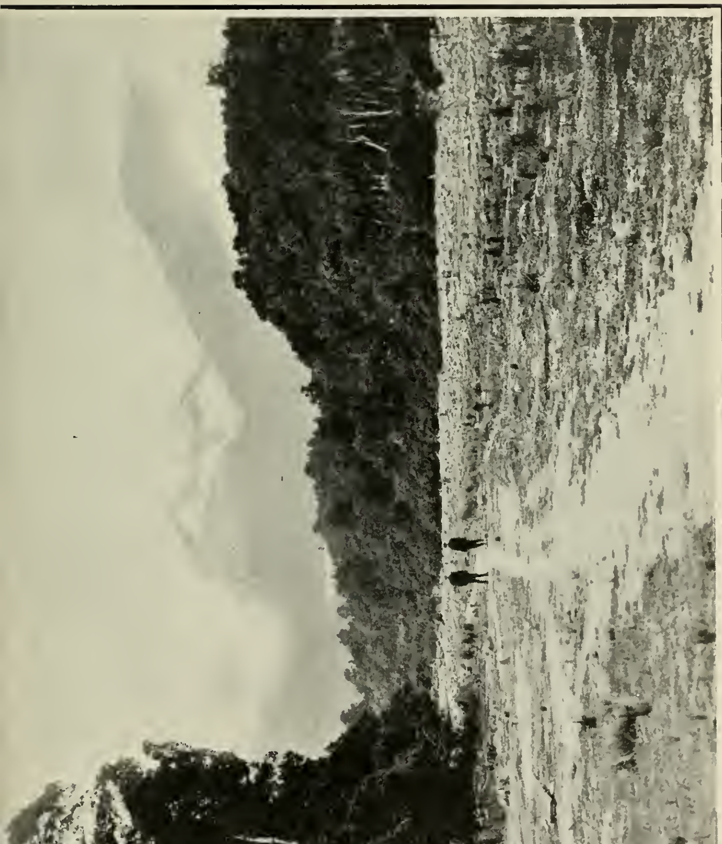


Photo. N.Z. Tourist Dept.

At Waiho: Looking up to the Franz Josef Glacier.

la Bêche, Mount Haidinger, Mount Haast, Mount Tasman, and Mount Cook.

The surface of the Tasman glacier is almost level. Crevasses are few—except opposite Mount De la Bêche, where a sudden descent in the level of the ice occurs—and the small ice hummocks that cover a portion of the surface do not offer any serious obstacle to a visitor. For the last four or five miles of its length the glacier is covered with moraine exposed by the rapid melting of the ice in this portion of its course.

The rate of flow of the Tasman Glacier is slow, amounting to about eighteen inches a day. This is in the middle of the glacier opposite the confluence with the Ball glacier. So far as measurements have gone, the terminal face of the glacier appears to be almost stationary.

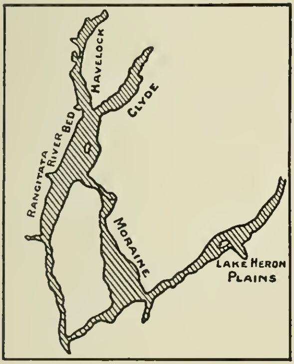
The average width of the glacier is 1¼ miles, so its total area is 15,000 acres.

The fall of the glacier from its source to its terminal face is 313 feet per mile, or from the foot of the nevé that feeds it, 188 feet per mile. Its terminal face is 2,354 feet above sea level.

The **Murchison** glacier lies on the east side of the Malte Brun spur, which separates it from the Tasman glacier. Its valley joins that of the Tasman five miles above its terminal face, but the terminal face of the Murchison is situated five miles above the junction of the valleys. Its length is 11 miles, and breadth over three-quarters of a mile. Its rate of motion, measured near its terminal face, is seven

inches per day in the centre of the glacier. Its terminal face is 3,452 feet above sea level.

The **Hooker** glacier is separated from the Tasman by the Mount Cook spur. Its length is 7¼ miles, and breadth ½ mile. Its terminal face is 2,882 feet above sea level.



The river bed and moraines of the Rangitata Valley. Compare with the map of Dusky Sound. (See page 82.)

The **Mueller** glacier lies in a valley that is almost a direct continuation of that of the Hooker, Mount Sefton being situated on the west of the junction. Its length is eight miles, and its terminal face 2,550 feet above sea level.

On the west coast glaciers are far more numerous than on the east side of the range. The longest of them are the **Fox** glacier, with a length of 9¾ miles, and the **Franz Josef**, 8½ miles long. All of these glaciers have, so far as is known, a very rapid rate of flow. Observations made on the Franz Josef at a distance of one mile from the terminal face give a movement of two feet per day. The total fall of this glacier is 1,064 feet per mile. Its terminal face is 692 feet above sea level, while the latitude is almost that of Florence. The terminal face is advancing at present.

The terminal face of the Fox glacier is 670 feet above sea level. Both of these glaciers have an

extremely rough, broken surface, which is almost free from moraine. This is accounted for by the rapid rate of flow and its highly crevassed nature. Owing to the former there is but little time for morainic matter to accumulate, and the latter allows much of the morainic matter to fall into fractures of the ice surface.

The extent to which ice has moulded the surface features of land that has been glaciated is a subject that has aroused much discussion in Europe as well as in New Zealand. At one time opinion granted almost unlimited **power of erosion** to glaciers. Now the most ardent advocates of the power of glacial erosion maintain that fiords and some lake basins only have been deepened and smoothed by glaciers, while it is the general belief of English geologists that the power of glaciers to change land forms is summed up in a polishing and rounding of the rock masses over and around which they flow.

In New Zealand many indications show that the glaciers of the present day are only shrunken representatives of numerous immense ice masses that filled all the important valleys of the mountains in the central and southern portions of the South Island. The occurrence of **fiords** and **deep lake basins** in this area is at once noticeable. Where neither of these occur—as in South Canterbury—the mountain spurs are still found to be sundered by profound valleys of great breadth. In these valleys rivers flow over broad shingle beds, while high up on the mountain sides can be seen terraces that represent lateral moraines of the glaciers that once filled the valleys. In most cases the rivers leave

these deep, broad valleys through narrow gorges in which living rock forms the bed of the river.

The presence of the broad gravel-bottomed valley above, and the narrow gorge below, prove that they were not formed by the rivers that flow in them, unless the lower ranges pierced by the gorges have only recently been elevated. The broad gravel bottom of the upper valleys proves that in this portion they were once much deeper, and have since been filled by gravel.

The original form of these valleys must therefore have been similar to the present basin of Lake Wakatipu and of the West Coast Fiords.

It is remarkable that throughout the southern part of the South Island, on both flanks of the main range, fiords, lake basins, and river valleys are found, each of them in depressions of a similar character. Elsewhere in New Zealand no depression of this type occurs. The coincidence of the occurrence of these valleys throughout the region where the glaciers have been largest and most abundant and their complete absence elsewhere are at once suggestive of their connection with glacial erosion. The fact that all these valleys have been occupied by immense glaciers strengthens this view. In Queen Charlotte Sound—which affords us an undoubted instance of the form of river valleys in a mountainous district that has been depressed—the difference of form above and below water level is most marked when compared with a West Coast Fiord, Lake Wakatipu, or the Rangitata valley.

The explanation most commonly accepted of the cause of the shape of these valleys would require a

depression of the central mountain mass or an elevation of the two flanks. No observations have been hitherto made in New Zealand that support this view. So far as such a matter can be estimated without exact measurements, it appears that the terraces at the upper ends of these valleys are as numerous and as elevated as those at the lower ends. If these observations are confirmed by subsequent measurements, the theory of the formation of the basins by unequal land movements will fall to the ground, and the opposite theory of their formation by glacial erosion will be strongly supported.

In other respects, the action of the huge glaciers on the land forms in New Zealand has left but little effect. The piling up of morainic masses in many valleys has blocked the drainage, and **lakes** have been formed, often of large extent. The rocky sides of the valleys mentioned have been smoothed and rounded. On the floors of some of them, "roches moutonnées,"—large rounded rocks like huge sheep—have been left. Nowhere are any signs to be seen of the country having been overwhelmed by ice as in North America. At the Taieri however the terminal face of a large glacier almost reached the present sea shore.

Chapter VIII.—LAKES.

Formation.—In a country with a moderate rainfall, any portion of the surface that lies below the level of the surrounding land, through which no outlet leads, will be filled with water that flows into it from the land around.

These inland sheets of water, or lakes, cannot exist long, for the mud, sand, and gravel carried into them by streams gradually accumulate, and at last fill them. Lakes are, therefore, transitory features in a landscape, and the process of their formation must be more rapid than the deposit of sediment by which they are finally filled. The size and form of lakes vary indefinitely, though there is often some relation between the form and the cause to which the basin of the lake is due. Lakes formed by any one agency generally have a family resemblance in shape, and often in depth.

The following is a convenient **classification** of lakes:—

1. Lakes formed by the banking up of sand or shingle on a coast line. These are usually very shallow, and often their water is salt.

2. Lakes formed by obstruction extending across drainage channels.

(*a*) Wind-blown sand.
(*b*) Lava streams.
(*c*) Gravel and mud deposited by streams.
(*d*) Glacial moraines.
(*e*) Landslips.
(*f*) Ice.

3. Small lakes are formed at times in volcanic craters.

4. Subsidence of a portion of a land surface may sometimes take place rapidly, and a lake occupies the depression that results.

5. Warping of the rocks extending across a stream valley may sometimes elevate a bar across

the lower portion, so that the upper portion of the valley is filled by a lake.

6. A glacier sometimes corrodes one portion of its valley more deeply than others. After the ice melts, this deeply-corroded portion becomes a lake.

7. When the bottom of any marine area is elevated into dry land, the depressions that often exist in it become lake bottoms.

8. Faults, or rock fractures and dislocations, sometimes have an important effect on the earth's surface. Depressions, or rift valleys, are occasionally found along the lines of fracture.

The lakes of New Zealand, varied in form and appearance, afford examples of almost all these well-known methods by which lake basins are formed. Although, so far as known, none of our lakes fill rift valleys, and none represent oceanic depressions, one or more of them can be referred to as typical of each of the other origins mentioned.

So far as a distribution is concerned, the lakes are scattered far and wide over the country.

From the extreme north to the extreme south, there are few districts devoid of lakes; and they are numerous in the southern portion of the South Island and the southern portion of the Auckland Province. (See maps pp. 131, 149.)

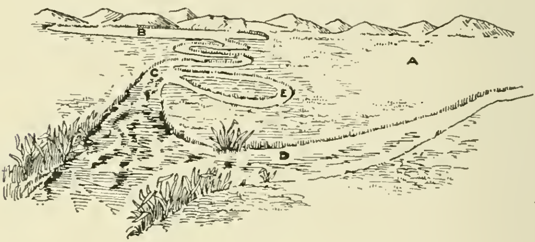
They are sometimes of large size; Lake Taupo, for instance, covers 238 square miles, Te Anau 132 square miles, and Wakatipu 112 square miles. The level of the lake system is often a considerable height above sea level. Lake Pukaki is 1,588 feet, Tekapo 2,321 feet, Taupo 1,211, and Wakatipu 1,059 feet above sea level.

Some of them are extremely **deep**, the bottom even reaching some distance below sea level; Lake Wakatipu's floor is 180 feet, Manapouri's, 861 feet below sea level, while its surface is only 597 feet above it. Lake Taupo on the other hand, does not nearly reach to such a low level, for it is only 534 feet deep and its floor is thus 677 feet above sea level. Lake Waikare Moana in Hawke's Bay is the deepest lake in the North Island. It is 848 feet deep, but its surface is 2,015 feet above the sea level.

1. The drift of shingle along the coast is stopped by any projecting point, for the velocity of the ocean current is reduced and its transporting power lessened. On the east coast of the South Island, the drift from the south is opposed by Banks Peninsula and the shingle has been deposited. As more and more material was added to it, the shingle bank grew southwards and enclosed a large area of lowlands. Inside this barrier a lagoon or lake has been formed. The waters are fed and kept supplied by the Selwyn River and other streams. From time to time the pent-up waters break through the shingle barrier and rush out, and afterwards the rise and fall of the tide makes salt water flow in and out of the entrance that the outflow made. The lagoon is thus salted and the breach in the barrier is filled by the gravel thrown across it by the sea and once more the waters accumulate. Lake **Ellesmere** and Lake **Wairarapa** are the best New Zealand examples of this type of lake.

2. (*a.*) Drifting sand impelled by a prevailing wind marches slowly along the coast in the form of dunes or sandhills sloping gently towards the wind

and abruptly on the other side. When the dunes extend across stream channels, the sand is wetted and does not move on easily. Plants grow on the sand and a permanent barrier results. The water at first leaks through the sand, but the small particles of solid matter it carries soon clog the small spaces betwen the sand grains and the water collects into a lake. Many small lakes of this nature exist near the sea coast on the west side of the North Island.



Anabranch in Waihola River, near Taieri.
A. Taieri Plain. B. Lake Waihola. C. Waihola River.
D. Taieri River. E. Anabranch of Waihola

For thirty years two of these, **Virginia** and **Westmere**, provided the source of water supply for Wanganui, a town of 6,000 inhabitants.

(*b*.) Near Auckland the miniature volcanoes have sent forth many lava streams. These soon flowed into the stream channels and blocked them up. In one of these Lake St. John was formed by the dammed-up waters. In the same way the lavas from Tongariro blocked up a stream between that volcano and Pihanga. Thus was Lake **Rotoaira** formed.

(*c*.) In river beds where the main stream has reached its base level of erosion and the rate of deposition equals that of removal of material, an

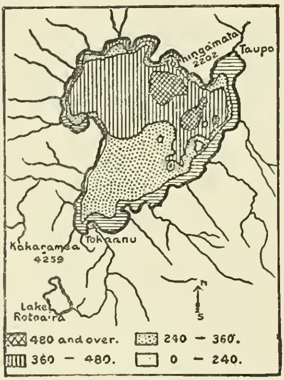
active tributary may block the stream it joins, and a lake will then form in the main stream behind the barrier. The main stream in other cases blocks up some of its tributaries in the same way and lakes are formed in the valleys. Sometimes, a stream with a meandering course may cut through the narrow neck of the meander and the old curved channel is at first an anabranch taking but little of the water;

Crater lake of Mount Ruapehu.

before long its connections with the main stream are blocked up by mud, and a curved lake results. The lakes in the **Waikato valley** (see map, p. 142) occupy the valleys of tributaries and in the **Waihola** River near the gorge an anabranch has been formed, but the ends are not yet silted up, and there is a similar instance in the Waitotara River.

(*d*) The mighty glaciers that long ago filled the mountain valleys have left many traces of their former presence. Their large terminal moraines have

blocked up the valleys of many mountain rivers and some of our largest lakes now occupy the valleys in which the ice flowed; for example, Lakes **Coleridge**, **Pukaki**, **Tekapo** and to some extent **Manapouri** and **Te Anau**, though it is probable that the two last have their floor far below the base of the morainic accumulations that are found alongside of them. Smaller lakes in almost countless numbers in the south of New Zealand owe their origin to this cause.



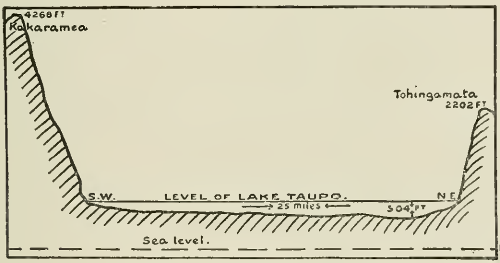
Map of Lake Taupo, showing depth.

(*e*.) Ice constituting the mass of a great glacier may sometimes form a barrier across another valley. A lake forms behind the barrier, but it is unstable and may almost at any time burst the icy barrier that restrains it. There is no lake of this kind in New Zealand now, though there is reason to believe that they were large and important when the glaciers were more extensive.

(*f*.) In steep-sided valleys rock-falls or landslips occur from time to time and temporary lakes form behind them. Lake **Ada** in Milford Sound is of this type.

3. The large number of volcanoes in New Zealand, many of which still preserve their original form and possess deep craters, suggests that this type of lake would be common in the country. This

is, however, rarely the case, for many of the craters have walls of loose scoria which allows water to soak through it readily. Lake **Takapuna** on the North Shore of the Waitemata Harbour is however a good example. **Ruapehu**, the largest volcano in New Zealand, has a hot lake in its crater. The lake is 8,500 feet above sea level. Surrounded by cliffs of ice the water of the lake is kept hot by the jets of steam that rise through the throat of



Section of Taupo from S.W. to N.E.
Length, 1 in 300,000: depth, 1 in 30,000.

the slumbering volcano. Between the ice cliffs and the hot water there is a small beach, but this does not prevent the ice from being undermined and from time to time falling into the lake.

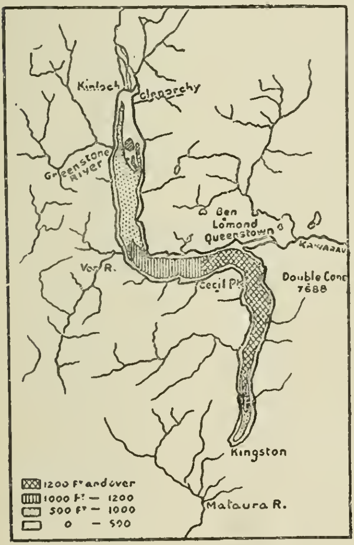
4. The volcanic eruptions that have taken place so frequently and with such energy in the North Island have apparently erupted material that afforded support for sound portions of the crust. When the support was removed to the surface in volcanic outpourings, the unsupported portion of the earth's crust subsided and large depressions were formed in which water soon collected. Lake **Taupo** lies in a huge basin of this nature. Lake

Head of Lake Wakatipu. Pigeon Island in the foreground, Mount Earnslaw in background.

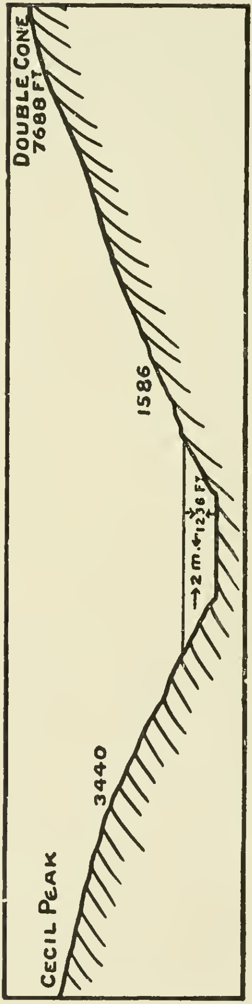
Rotorua occupies another, and in places on the shores of both of them the stumps of forest trees may be seen still upright in the submerged soil. It is probable that the other lakes near Rotorua were formed in a similar way. In June, 1886, the great explosive eruption at Rotomahana formed a huge depression which has now been filled with water and forms a lake four miles long and two miles wide. This experience suggests a similar origin for Taupo, Rotorua, etc.

5. If the lower portion of a stream valley is tipped up, a lake

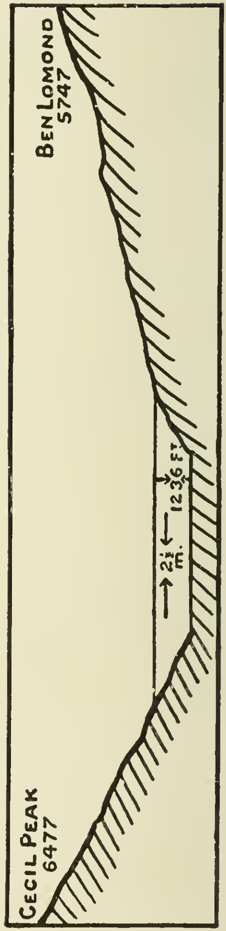
may be formed in its upper part, and if the land movements are sufficient, the lake may become extremely deep. Such movements are slow, and as they proceed, the lake deposits successive beaches at the various levels to which the waters reach. These beach terraces will show a gradual slope from one end of the lake to the other. It has been lately shown that the great lakes of America owe their formation to such warping and it is generally believed that Lakes Geneva, Constance, Como, and others have a like origin. In New Zealand Lakes **Wakatipu** and **Manapouri** and others would be accounted for by Continental geologists in this manner. The great depth of these lakes would imply considerable movements of rock, and such movements could hardly be of a purely local nature; so it would be expected, if this were their origin, that neighbouring valleys, whose number is legion, would be affected in a like manner and be changed into lake basins. No slopes have yet been measured on the terraces that surround Lake Wakatipu, but those at the upper end of the lake do not appear to



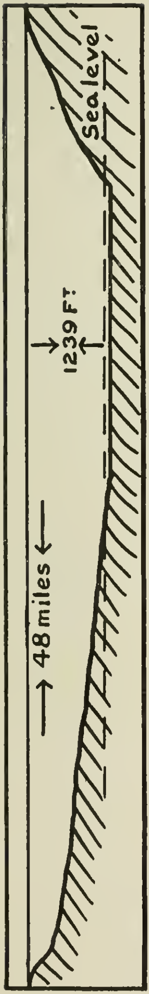
Map of Lake Wakatipu, showing depths. After Keith Lucas.



Cross section of Lake Wakatipu. Vertical, 1 in 100,000; Horizontal, 1 in 100,000.



Cross section of Lake Wakatipu. Vertical 1 in 100,000; Horizontal, 1 in 100,000.



Longitudinal section of Wakatipu along axis of greatest depth. Vertical, 1 in 600,000; Horizontal, 1 in 30,000.

have a less elevation than those at its lower end. In the present state of our knowledge observed facts do not seem to support such an origin as that described.

6. Glaciers have been described previously, and the fact that their most rapid corrosion is performed where their ice is thickest was insisted on. It is generally accepted that the shape of a glacial valley is that of a **U** in section, as distinct from that of a **V**, which is typical of stream valleys. Many lakes in the South Island lie in old glacial valleys, and the two that have been completely sounded have been shown to be typically **U** shaped in section, being steep at the sides and broad and flat at the bottom and sloping down gradually from both ends. This is the exact shape that would be expected if their form was due to the action of the ice that flowed in them. The sides of Lake **Wakatipu** have exactly the same slope below the water as above it, and deep though the lake is, its depth is a very small matter compared with its length. Until other facts are forthcoming, it seems reasonable to suppose that Lakes **Wakatipu**,

Manapouri, Te Anau, Monowai and others like them have had their basins formed by glacial erosion rather than land warping.

The New Zealand lakes have had but little influence on the **distribution of the population.** Some of them were used by the natives as fishing grounds and small villages were established on their shores. They are not situated in fertile or rich pastoral or agricultural districts, so they have no large towns near them, and their waters are not used as important highways of communication.

The peculiar scenery of the hot lakes in the North Island has attracted a large number of visitors to them. The township of Rotorua owes its existence to this fact. The settlements of Tokaanu and Tapuhaeruru on Lake Taupo would hardly exist if the stream of tourist visitors ceased.

In the south the majesty of the precipitous mountains bare or covered with bush, gives a charm to the lakes that yearly attracts an increasing number of visitors. On Wakatipu several steamers are run by the Government, and the township of Queenstown is mainly supported by the summer visitors attracted by the grandeur of the scenery. Though this lake is in some respects less striking than its neighbours, it is much more generally visited and is better known because of the facilities for travel offered to those who wish to see it. The number of trout in Lakes Taupo and Rotorua at present attract sportsmen from all parts of the world.

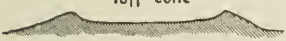
CHAPTER IX.—NEW ZEALAND VOLCANOES.

Formation.—A volcano is a natural elevation formed of materials ejected from the deeper portions of the earth.

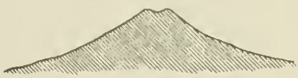
The material ejected is solid, liquid, or gaseous. The **gaseous** matter escapes into the atmosphere, and does not add to the size of the elevation formed of the volcanic matter. The gas is nearly all steam. It condenses into torrential rain-falls, which deluge the country around volcanoes after periods of activity.

The **liquid** matter is molten rock, called **lava**, always at a very high temperature (2,000° C). This

Tuff Cone



Scoria Cone



cools rapidly after it has reached the earth's surface. As it cools, it solidifies and accumulates in greatest quantity in the immediate neighbourhood of the orifice through which it was ejected, and thus tends to form a conical elevation sloping outwards in all directions from the point whence it issued. Sometimes the lava is highly viscous, at other times it is comparatively mobile. In the latter case it may flow for great distances, and the cone that it forms will have a flat shape. When the lava is highly viscous, it solidifies before it has had time to flow any distance. It therefore forms cones of great steepness.

The **solid** matter consists of small fragments of rock, sometimes pieces of the rocks forming the crust of the earth directly beneath the volcano, but more frequently fragments of lava crusts that form over the lava when activity is slight, and are broken up when steam bubbles commence to burst through it again. The bursting of the steam bubbles scatters the fragments over the surrounding country.

Mount St. John, Auckland: a scoria cone.

The **shape** of a volcano is at first conical in all cases. The sides slope upwards with a beautiful parabolic curve, nearly horizontal at the base, and attaining an inclination of 40° at times near the apex. (See photograph of Egmont, page 14.)

Sometimes during a period of dormancy the upper portion of the lava in a volcanic pipe solidifies into hard rock, through which the steam below cannot escape. The steam accumulates below this hardened

rock, and finally its pressure becomes so great that it overcomes the resistance of the rock above. A tremendous explosion then takes place, and the whole summit of the mountain may be hurled into the air, and a huge yawning cavity left in its place.

When the activity has entirely ceased, the agents of corrosion and decay despoil the symmetry of form. Streams wear their channels deep into its slopes, and in time all the beautiful conical shape of the volcano disappears, and nothing but the nature of its rock

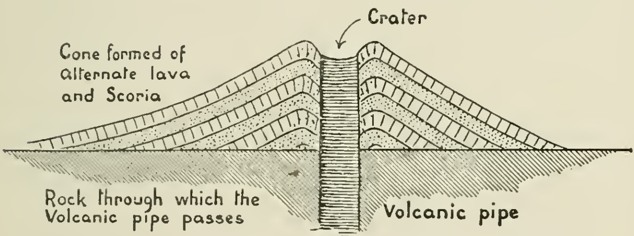


Diagram of Volcano when crater has become an inverted cone.

distinguishes the once towering volcano from the surrounding hills of the country near.

Classification.—Volcanoes are sometimes **classified** as active, dormant and extinct. This is unsatisfactory, as many instances are on record of the sudden and violent activity of volcanoes that had been previously supposed to be entirely extinct.

A **Solfatara** is a volcano whose activity is limited to the escape of steam and sulphurous gases from its crater.

When the fragments ejected from a volcano are very minute, they form deposits almost as regularly arranged in layers as if laid down beneath a water surface. Such formations are called **tuff.** This fine material is produced in great quantity by violent

explosions, and is scattered far and wide by the wind. It is brought down from the air by the showers of rain that result from the condensed steam that issues from the crater with the fine dust. The coarser material, composed chiefly of the shattered lava crusts falls near the volcano, and adds greatly to the steepness of the volcanic cone. It is called **scoria**, and in some cases composes the whole material of a volcanic cone.

When steam bubbles burst on the surface of the lava, fragments of the bubble skin may be projected violently by the force of the bursting. These fragments rotate rapidly as they pass through the air and acquire a spheroidal form. They are the so-called volcanic **bombs**. In New Zealand they are found in great abundance and perfection on the slopes of many of the small volcanoes near Auckland.

Nearly all volcanoes are composed of alternating layers of these various materials. Sometimes one, sometimes another predominates, and usually the main part of the cone is formed of lava sheets separated by scoria beds.

It has been already stated that this volcanic material solid, gaseous, and liquid—has come from the deeper parts of the earth's crust, or from its still molten interior. In most cases it is probable that it passes upwards through a vertical passage circular in cross section. This is the volcanic pipe.

As a volcano grows, the passage or pipe must continue to reach to its crest, and its actual length is consequently always increasing. The explosion of bubbles of steam that are always rising through the pipe whilst the volcano is active serve to keep its

orifice clear of accumulated matter. Thus a depression exists at the summit of a volcano with the shape of an inverted cone, which is its **crater**. The crater is usually conical, because the scoria ejected by the bursting steam bubbles accumulates in greatest quantity round the edge of the orifice of the pipe. As it accumulates, a circular ridge is formed with a slope inwards towards the orifice and outwards towards the surrounding country. When activity is great, the constant explosions and violent ebullition of the lava prevents the encroachment of

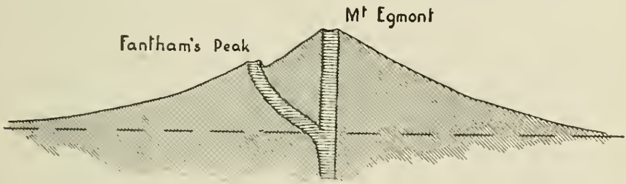


Diagram of Mount Egmont.

the scoria on the molten lava, but when activity gradually dies away, the encroaching scoria advances further towards the centre of the orifice, and finally opposite slopes meet, and the crater becomes a complete inverted cone.

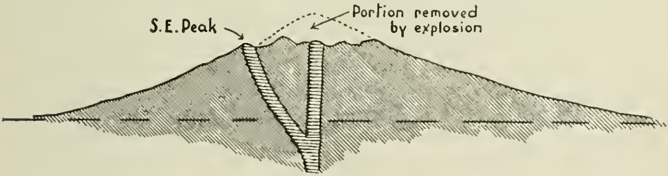
The scenery and surface features of a large area of New Zealand have been formed as a result of volcanic activity. In the South Island **Banks Peninsula** and **Otago Peninsula** are almost entirely of volcanic origin, and there are numerous other localities, such as **Mount Somers** in Canterbury, and the many isolated hills near **Palmerston South** that are chiefly formed of volcanic rocks.

In the North Island, all the **central portions**

Mount Ruapehu, 9,150 feet. Looking north-west.

extending from Mount Ruapehu in the south to the Bay of Plenty on the north-east and to the middle Waikato on the west, is volcanic. Again **near Auckland** there are miniature volcanoes of great variety and perfection, and in many areas on the Northern Peninsula volcanic action has been the chief agent in fashioning the surface features of the country.

In the **Otago Peninsula** volcanic action has been so long extinct that all the characteristic external



Section through Mount Ruapehu.

form has been completely lost, and it is only by close examination of the rocks that any conclusion as to the position of the cones and craters can be arrived at.

Mount Somers is still more ancient, but **Banks Peninsula** shows some of the contours so distinctive of volcanic origin. Lyttelton Harbour is a gigantic crateral hollow formed by the violent explosion that results, as previously explained, from the sudden expansion of long imprisoned steam. After the formation of this crater with the removal of the whole mountain crest that formerly extended over the present harbour an eruption took place on its rim, and Mount Herbert was formed, and still later a smaller eruption on the crater floor resulted in the formation of Quail Island.

A similar development has occurred on the south side of the Peninsula, and Akaroa Harbour is the result of it.

In the North Island volcanic action has had greater influence in the development of the present land features. Over an area of 20,000 square miles the present surface of the country is almost a direct

Ngauruhoe ejecting dust to a height of 3000 feet in March, 1907.

result of the energy of volcanic eruptions, modified only as regards some of its minor features by the influence of water erosion.

In most portions of this area volcanoes stand out prominently, and the largest of them attains a greater elevation than the highest peaks of the true mountain ranges formed of folded rocks. The majority of the volcanoes are true cones, with the typical outline seen in its finest development in the

beautiful curve of the symmetrical giant cone of **Mount Egmont.** This mountain forms a projecting promontory on the western coast, far outside the connected volcanic area, but there is no doubt that the eruptions that built up the mountain were simulaneous with some of the volcanic activity in the main area.

Ngauruhoe from the east, three miles distant, January, 1911.
At this time there was lava in the water.

Mount Egmont's height is 8,250 feet; so it rises above the level of perpetual snow, and its crater, now, so far as indications go, quite extinct, is filled with congealed snow and ice. The perfect symmetry of its flanks is interrupted on the southern side by the small parasitic cone of Fantham's Peak, and on the northern by the Pouakai Ranges.

The formation of **Fantham's Peak** is illustrative of a typical phase that often destroys the form of a volcano towards the end of its active career. As a volcano grows, the orifice of its pipe reaches higher and higher above the sea level, and when it is filled with lava, the pressure that is exerted outwards near the base is enormous. Sometimes the mountain, trembling with the force of steam explosions, is not strong enough to withstand this pressure, and gaping rents are formed in its sides, through which the lava flows. At the points where the lava flows from the mountain's side the ordinary phases of volcanic eruptions are displayed, but usually on a minor scale, and small parasitic cones result. It is said that eighty parasitic cones have thus been formed on the slopes of Mount Etna.

In the extreme southern portion of the great volcanic area of the North Island the volcanic group of mountains, **Ruapehu** 9,150, **Ngauruhoe** 7,515, and **Tongariro** 6,458 form the most important geographical feature. The three mountains are arranged along a line running south-west and north-east, parallel in fact to the range of folded mountains that forms the backbone of the island. The line continued north passes across Lake Rotoaira, through Mount **Pihanga** across Lake Taupo and through Mount **Tauhara**. Both these mountains are volcanic and their arrangement in a line continuous with that on which the more southern giants are situated suggests that there is here a line of weakness in the earth's crust which has offered an opportunity for the volcanic forces within to find an outlet for their energy.

Ruapehu has not such a simple outline as Mount Egmont. Its summit appears to have suffered from an explosive effort similar to that by which Lyttelton Harbour was formed, while the south-east peak is a parasitic cone that now has almost as great an elevation as the truncated remnant of the main mountain.

The mountain rises 1,500 feet above the level of perpetual snow. The upper portion of its flanks supports snowfields and in some of the valleys true, but small glaciers are found. The interior of its truncated summit is occupied by an icefield in the centre of which there is a hot lake 200 yards in diameter. Through the water steam constantly rises and the heated water undermines the ice cliffs round it and from time to time blocks of ice fall in and rapidly melt.

Ngauruhoe is a perfect cone, though on its northern side Tongariro interferes with its slopes 2,500 feet below the summit. The mountain is still active, though its activity is usually that of the solfatara stage of a volcano. Occasionally, spasmodic fits of more violent activity occur and showers of solid matter are shot up into the air and accumulate as thin beds of scoria and tuff on the mountain sides. Occasionally, as in 1895, Ruapehu joins in and dark scoria is deposited on the white snow that covers the top of the mountain. No lava has issued from either volcano since the mountains have been known to English travellers.

Tongariro has suffered the same catastrophe as Ruapehu, and its summit is now occupied by several craters, two of which are in the solfatara stage,

while on the northern side there is a large area—Te Ketetahi, whence hot springs and steam jets issue.

The very numerous smaller volcanoes of this area need no special description. Their history has not differed in any important respects from those mentioned and described. **Pihanga, Tauhara, Edgecumbe,** on the south and east of the volcanic area, show almost the perfect symmetry of normal cones. On the west **Kakepuku** and others are similar. Still further west **Pirongia** and **Kerioi** are cones that have suffered the same catastrophic explosion as Ruapehu.

Near Rotorua the volcanoes are flat topped. **Ngongotaha** is the most prominent, and so pronounced is this shape in **Horohoro,** that its appearance suggests that it is a block mountain, though no geological facts in favour of this are known.

White Island in the Bay of Plenty is a simple cone in the solfatara stage. It rises from comparatively shallow water, but only its apex reaches above the ocean's surface.

Tarawera, a flat-topped mountain near the shores of Lakes Tarawera and Rotomahana, was, previous to 1886, considered an extinct volcano similar to Ngongotaha and Horohoro. On June 10th, 1886, explosions were heard proceeding from the top of the mountain. A few hours later these were succeeded by tremendous detonations. Immense volumes of steam shot up into the air and huge clouds of dust followed. The cloud at first advanced

Rift in the summit of Mt. Tarawera formed during the explosive eruption of June, 1886. See p. 206.

to the north-west, but a change of wind drove it to the north-east, and the light dust spread in a thin layer over a huge area of country extending to Tauranga, where there was complete darkness at midday, though it is 75 miles from the mountain.

Subsequent exploration showed that the summit of the mountain was rent in twain and a huge chasm extended south-west from its foot. The chasm was 12 miles long and ¼ mile broad; it included the depression previously occupied by Lake Rotomahana. Activity continued for some months at the summit of the mountain and in the chasm, and eight small scoria cones were built up. There was, however, no return to violent activity. The eruption completely destroyed the beautiful sinter terraces at Rotomahana, which previously had been the chief scenic attraction of the district.

Activity gradually decreased in the chasm thus formed and finally resolved itself into a series of hot springs and steam jets. Of late years the huge mud geyser **Waimangu** has reproduced in a faint manner some of the characters of the district when its disturbance had declined after the great eruption.

Geographically the eruption altered the surface features of a large area on the south and west side of the mountain. The country was completely covered with pumice—a light vesicular scoria and dust, which has now consolidated into a bed of tuff, the surface of which has been scored into a complete series of miniature hills by rainfall. Lake Rotomahana was for a time almost obliterated, though now it is larger than before, as its outlet

has been blocked by the accumulation of pumice, and the water thus dammed has spread over much of the surrounding land.

The narrow **isthmus** connecting the northern peninsula with the southern portion of the Auckland province is studded with a profusion of miniature volcanoes. The district was examined carefully by Hochstetter in 1862. He divided the volcanoes into **three groups**—tuff, scoria, and lava cones—though some combine the characters of two or of the three types. The tuff volcanoes have a low cone with a very gentle inclination and a large crater.

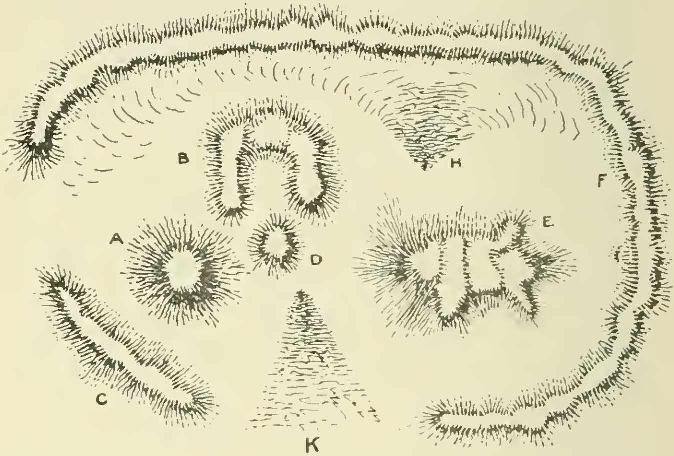
Mount Rangitoto: combination of lava cone A, and scoria cone B

The scoria volcanoes reach a height of 500 feet and their sides are steeply inclined.

The lava volcanoes are represented in their most perfect development by **Rangitoto**. The lava was apparently very liquid, so the angle of slope is low, but it has flowed almost equally in all directions, and the symmetry of the island volcano is almost complete. After the active life of Rangitoto it became too exhausted to allow it to eject any more lava, scoria eruptions took place within its crater, and a scoria cone that now occupies the crest of the mountain was formed.

The **Three Kings** volcano near Auckland offers a splendid example of the combination of lava scoria and tuff volcanoes. The first tuff eruption formed a low crater wall nearly half a mile in diameter, much

of which is still visible. Lava eruptions then took place and the crater was almost filled with molten rock. Some of the lava escaped over the north-east



Plan and Sketch of Three Kings Volcano. C.F.: Tuff crater wall.
A.B.D.E.: scoria cones. H.K.: lava flows.

side of the tuff wall and flowed for a distance of four miles. Afterwards four or five scoria cones were formed within the area of the original tuff crater.

Mount Eden has lower slopes of lava and its

summit is crowned with a scoria cone. The lava has entirely covered the original tuff on all sides but one.

The basin at **Onehunga** is a good example of a simple small tuff crater, and **Mount St. John** has the form of a typical scoria cone. **Mount Hobson** is also a scoria cone, but its crater was breached by a lava flow, which issued on the south side but had small extent.

The growth of these small Auckland volcanoes was probably a rapid process. Monte Nuovo on the shore of the Bay of Naples, very similar to some of the scoria cones, was built up in four days.

Groups of small volcanoes rather like these Auckland examples have often been described and illustrated. A well known example occurs in Auvergne and there all the separate volcanoes are called puys.

The volcanic country to the north of Auckland presents no very unusual features. Many of the volcanoes near Hokianga and the Bay of Islands are comparatively recent and still possess intact their perfect development of symmetrical cone and crater. None of them has shown any signs of activity since European settlement, nor are any eruptions recorded in Maori traditions.

Volcanoes and Distribution of Population.

The soil that is formed by the decay of volcanic rocks is usually extremely fertile. Consequently in districts where the volcanic action is extinct or dormant a dense agricultural population is generally found. In the majority of instances the volcanic

country is hilly or even mountainous and fit only for pastoral occupations. New Zealand affords many instances of the fertility of volcanic soils when compared with the soils around them. In Auckland the volcanoes have burst their way through the heavy clays of an old sea bottom. The patches of volcanic soil are well settled and bear rich crops of all kinds, while the clays around them are barren.

The hilly country of Banks Peninsula and Otago Peninsula is covered with farms which support a fairly large population, who grow large crops of grass-seed and have numerous dairy factories. The soil of Otago Peninsula is especially rich when compared with that on the schist rock hills that stretch far inland from the coast.

Where volcanic action is still in progress or has but recently ceased, the population is scanty. The plant food stored up in the rocks has not been released by the action of air and rain. Hard unweathered rocks form the surface and no soil has formed. Where the volcanic matter consists of loose fragments, stony slopes are formed. Until they are gradually changed into clay or soil, but little vegetation can grow on them, so the land remains barren and the population scanty. This is the case over the greater portion of the volcanic plateau of the North Island.

In regions of volcanic activity, especially in its later phases, hot springs abound charged with many chemical compounds of a healing and beneficial nature to human ailments. Spouting geysers, too, are found, and from their waters are deposited

terraces and slopes of white silica. All of these attract many visitors, and townships may arise in the barren land. They are dependent upon richer districts for much of their supplies, though by irrigation and tree planting the barren soil around is made to yield some produce.

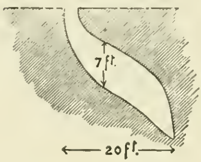
Chapter X.—THE GEYSERS AND HOW THEY WORK.

(*J. W. GREGORY, D.Sc., F.R.S.*)

General Characters.—The most marked feature in the present stage of the volcanic history of New Zealand is the activity of its geysers. The volcanic region around Lakes Taupo and Rotorua includes the largest of the three geyser fields of the world, and until recently the most powerful geyser known.

A geyser is a hot spring, which at regular or irregular intervals spurts a column of water or mud high above its mouth. Each geyser consists of a **well**, which may be cylindrical, or consists of a series of irregular, cave-like chambers. Thus one of the extinct geysers at Whakarewarewa, according to the measurements by Inspector Corbett, has an inclined chamber 7 feet high by 20 feet long, and 12 to 14 feet wide. At the top of the well of the geyser is a round opening—the **vent**, through which the water is discharged. Above the vent, there is usually a shallow cup, or **basin**, on the

summit or raised **mound**, which has been built up around the vent. A geyser, therefore, consists of the same essential parts as a volcano. A geyser, in fact, is a volcano, which discharges water instead of molten rock. They are linked to ordinary volcanoes by mud-geysers, which shoot forth material intermediate between the water discharged from geysers, and the molten water-saturated rock discharged from most volcanoes. The mound of rock, which in time surrounds the mouth of the geyser, is built up by the deposition of silica. The water discharged from the geyser contains in solution some silica, derived from the rocks, through which the water percolates, on its way to the geyser well. It was at first thought that the silica of the mound was deposited by the cooling of the water, as sugar is deposited when hot water, which contains as much as it will dissolve, is allowed to cool. But in the case of most geysers, and probably in all of them, the silicious rock of the geyser mount is built up by the action of plants, which live in the boiling spring: they extract the silica from the water, and deposit it, grain by grain, around the geyser mouth.



Section across a Whakarewarewa Geyser.

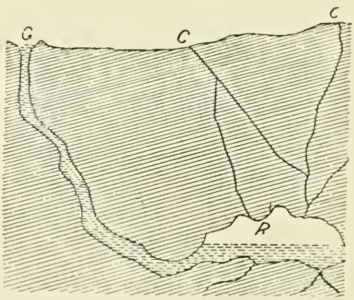
The word geyser is Icelandic, and is variously interpreted as meaning to gush, to roar, to rage, or to break up suddenly. The name was given to three members of a group of hot springs and boiling pools at the head of the White river, about seventy miles south-eastward from Rejkjavik the capital of Ice-

land, and thirty miles from Hekla, the best known Icelandic volcano. The springs extend in a band, a hundred yards in width, and about one-third of a mile in length, along the course of the White river. There are about 70 hot springs which pour their water into pools, whence the water is removed by evaporation or overflow. Three of the springs, known as the Great and Little Geysers and the Strokr, discharge their waters at irregular intervals by explosive eruptions, which hurl their waters, accompanied by a vast cloud of steam, high into the air. After every explosion the geyser has a period of rest, during which its tube is refilled with water, and energy accumulates to cause another violent eruption.

The Great Geyser consists of a basin-shaped hollow, four feet deep and sixty feet across, on the summit of a mound of white rock (silicious sinter) some 20 feet high. In the centre of the geyser basin is a vertical well, 10 feet in diameter, and over 70 feet in depth. The basin is usually full of hot water, the temperature of which slowly rises till it is almost boiling; then the water suddenly boils over, the water in the centre of the basin being raised some two to four feet above its level at the sides, and thus flows over the rim. This ebullition is repeated often several times a day; but occasionally at intervals of a few days or a few weeks the discharge of the overflow waters is more violent. The mound trembles, there is a deep rumbling noise from below, which increases till it sounds like the discharge of cannon. The water begins to boil violently, and then, by a series of explosions the water is hurled from 100 to

sometimes as much as 340 feet into the air. Most of the water falls back into the basin, whence it is again discharged, and thus the geyser plays like a fountain for from three to six minutes, until the geyser basin and upper part of the tube are empty.

Causes.—Subterranean Reservoirs.—Several explanations of Geyser eruptions have been offered. The geyser-mounds stand on a sheet of lava; the surrounding country is composed of volcanic rocks, and shows abundant evidence of volcanic activity. Hence it was natural to connect these discharges to



a volcanic source, and attribute the heat to the passage of the water through beds of uncooled lava. The explosive character of the eruptions was first explained by Mackenzie, in 1811, who attributed the spouting of the geyser to the discharge of water from subterranean reservoirs by the sudden expansion of compressed steam. This theory assumed the existence of cavities (R) connected with the surface by a pipe (G). It was thought that hot water slowly percolated into the reservoir, compressing the steam that filled the upper part of it. When the expansive force of the steam is sufficient to lift the column of water in the pipe, leading from the reservoir to the surface, then the geyser was thought to blow off, as a locomotive does, when the pressure of steam in

its boiler is sufficient to lift the safety valve. The imprisoned steam would then escape up the outlet carrying the water with it.

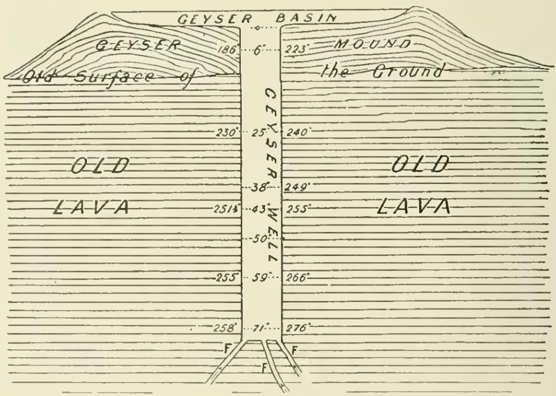
Superheated water.—This explanation is unsatisfactory, for the geyser wells were proved by sounding to be closed below, so that there is no passage into any hypothetical reservoir. It became unnecessary to assume the existence of these reservoirs, when a French geologist, Rovert, discovered that the temperature of the water in the well of the geyser was at a higher temperature than that at which water boils under ordinary pressure. Hence a relief of the pressure on the water in the lowest part of the well would enable the water to burst into steam as an explosive eruption.

The establishment of this theory is due to the observations of Descloiseaux, and the work of Bunsen and Tyndall. This theory, as is often the case, is more complex than the older and simpler hypothesis it replaced. It depends on the fact that water under pressure will remain liquid at temperature above the ordinary boiling point. Water, under such conditions is said to be **superheated**, and hot water at the bottom of the tube may be prevented from boiling, and thus kept superheated, by the weight of the water in the upper part of the tube. If the pressure be suddenly removed, then the water will burst into steam with explosive violence, and the water in the upper part of the tube be discharged in a geyser-like jet.

Hence, if the water at the bottom of a geyser tube is superheated, and either the load be reduced, or the water heated to a temperature at which the

weight of the overlying mass is insufficient to keep the lower water liquid, then the geyser will discharge by a sudden eruption.

This theory is in accordance with all the facts of the case, for observations have proved that the water in the lower parts of the geyser tube is superheated. The figure below represents a section across the Great Geyser, showing the mound of white



Section across the "Great Geyser" of Iceland.

geyser-rock, the wide shallow basin on its summit, and the well, the depth of which, according to various measurements, is between 72 to 80 feet. When the well is full to the top, then the lower water can be heated to temperatures above 212°, the ordinary boiling point of water, without being converted into steam. The numbers in the right hand column show the highest temperature, at various depths in the well, to which water can be heated without boiling. The observed temperatures of the

water in the Great Geyser at the same depths are stated in the left hand column. These figures show that the deeper water is superheated, and that the temperature just before an eruption is nearly at the maximum possible.

The cause of the explosive eruption.—The actual eruption is caused when the temperature of the water is raised to its boiling point, for then it suddenly explodes. The water can be brought to the exploding point, either by being further heated, or by a reduction in the load that is pressing down on it. These alternatives have both been claimed as the chief cause of the geyser eruptions. According to Descloiseaux, if a further supply of still hotter water is poured through the feeding channels (F) into the bottom of the geyser well; then the water, at say 15 feet from the bottom, may have its temperature raised above the limit of superheating at that depth (viz. 267°). The water will then burst into steam, and thus lift the whole of the water in the upper part of the geyser-well. And as the overlying water is raised, the pressure upon it will be reduced: and thus all the upper water is uplifted together to the level at which it will burst into steam. Thus if water at the depth of 43 feet in the well be raised 6 feet, it will have passed from the zone where the pressure is sufficient to keep it liquid, into the zone where it can be converted into steam. Thus the uplift of the water column by the boiling of some of the lowest water, causes the whole mass simultaneously to explode into steam.

Bunsen on the other hand, regarded the ascent of superheated water to the level at which it can boil,

as the real cause of the eruptions. If owing to any cause, the water at the depth of 43 feet rises 6 feet higher, it will have sufficient power to lift the load of water above it, and blow off, just as the pressure of the steam in a boiler lifts the safety valve. And as the sudden conversion of water, when it rises above the 38 feet level, lightens the load on the water below, that also is suddenly raised above its boiling point; and the whole of the lower 30 feet of the geyser water bursts instantaneously into steam. We can thus readily understand why the throwing of a mass of turf into a geyser will cause its explosion; for the fall of the turf starts currents in the water whereby some of it is raised above the level at which it can boil, and thus starts an eruption.

The heat that causes these geyser eruptions is no doubt due to volcanic agency. For the three geyser groups of the world are all in areas where there is abundant evidence of comparatively recent volcanic action. The Great Geyser in Iceland rests on a bed of lava, the geysers of the Yellowstone Park, in the United States of America, are in a region of extinct, but still of comparatively recent volcanic action.

The New Zealand geysers occur in the volcanic region around Lakes Taupo and Rotorua, in a region notorious for its volcanic explosions. The geysers occur in several localities, of which the three most important are Waimangu, and the geyser fields at Wairakei and Whakarewarewa.

Waimangu, the Black Geyser, was the greatest geyser in the world. It was situated in one of the craters formed by the eruption of Tarawera in 1886.

Waimangu Geyser shooting a column of water 1,600 feet high.

The geyser was first seen in eruption in February, 1901, and cannot have begun its activity much before that date. The tube is 80 feet deep, and it is situated in the middle of a small hot lake. It shoots up a column of inky black water accompanied by mud and boulders; the water is often thrown to the height of 300 to 500 feet, and its eruptions have been recorded as reaching the height of 1,500 feet, the eruptions occurring at very irregular intervals. The geyser sometimes lies dormant for a few weeks; but at other times, as during January and February, 1904, it continued in eruption for 4½ hours out of every 40 hours, the geyser playing for some hours before or after a major eruption. This geyser has been inactive since 1905.

The Geyser Basins of Wairakei.—The geysers of Wairakei occur on both sides of a steep narrow valley. They are mostly small, and are especially suitable for the study of geyser action, as they are easily controlled, and experiments can be conducted with them as safely as with a series of laboratory models. They well illustrate both the assumed causes of geyser action. Thus Descloiseaux's belief that the cause of a geyser eruption is the introduction of heated water from below, is shown to be a possible cause, by the geyser known as Feathers. This geyser is kept quiet, by letting a stream of cold water run into it; the temperature is thus kept below the superheated point, until an eruption is desired; the cold water is then turned off, the geyser begins to get heated up, and bursts into eruption at the time arranged.

The Lightning Pool illustrates Bunsen's view that

Waimangu Geyser, inactive.

the eruptions may be due to variations in the pressure of the overlying weight of water. This geyser has a pool of water 5 feet by 4 feet wide, and 5 feet deep. The temperature of the water is usually 204 dgrees; it is kept bubbling by the escape of steam from the hotter water below it. By opening a gap on the rim of the basin, the level of the water is lowered four inches. The pressure on the water in the well is thus lessened, so that the boiling point is reduced, and steam balls six inches in diameter rise to the surface of the water, which bounces up six inches above the level at the sides. The Champagne Pool has the deepest geyser well in this valley; the depth, according to Mr. Ingle, the guide, is 80 feet, at which depth, allowing for the height of the Wairakei valley above sea level, the boiling point of the water will be 269 degrees F.

Geysers near Rotorua.—The geysers at Whakarewarewa occur among a group of hot springs and mud springs, near the town of Rotorua. They are less active than they were before the Tarawera eruption of 1886. Before that event the most powerful geyser, Wairoa, or the "Long Water," spontaneously shot up a column of water 200 feet in height. At present the smaller ones may be almost continuously active; thus, in February, 1904, Waikunohihi had been playing steadily for nine days. But the great Wairoa Geyser now (1904) only plays when it is fed with bars of soap. The solution of the soap alters the tension in the water, and the geyser bursts into eruption. The geyser known as Waikite has now ceased to work; but an effort was made to restart it, by closing all the adjacent steam

vents but one. An earthquake followed, which occasioned a panic among the neighbouring Maoris; and as this was attributed to the force of steam thus artificially imprisoned, the apertures were reopened.

The life of geysers.—The length of the life of geysers may be considerable, but they are not immortal. The slow deepening of the well lengthens the water column, and the pressure on the lower layers of the water becomes too great for the heat to raise the water above the boiling point. The water therefore rises steadily up the well, and discharges as a quiet overflow, instead of as an explosive eruption. Thus every geyser is tending to pass into the condition of an ordinary hot well, and their life may be limited to a few centuries. The age of the Icelandic geysers is uncertain; but, according to some authorities, they are only a few centuries old, as there is said to be no record of their existence among the earlier annals of Iceland. And the experience of the geyser fields of New Zealand shows that they, like volcanoes, are very irregular in their activity, and that many of them in time become extinct.

Chapter XI.—EARTHQUAKES AND OTHER EARTH MOVEMENTS.

(*G. HOGBEN, M.A.*)

There is ample evidence that in New Zealand, as in other parts of the world, the land in past geological epochs has been alternately raised and lowered to a very considerable extent. For instance, in many parts of the colony there are extensive beds of coal,

which consist of the fossil remains of land plants. a proof that at the time the plants were growing that portion of the earth's crust was above the sea. The coal-beds generally occur at the base of a great marine formation, underlying limestones, clays, and sandstones of cretaceous and Cainozoic age, which have a thickness of several thousand feet; so that the coal-bearing strata must have afterwards been submerged for a considerable period beneath the ocean in which these overlying rocks were formed. Now they are found far above the sea, in some places —as in the Buller district— as much as 3,000 feet above sea-level. Hence the land must have risen again considerably, for it is out of the question to suppose that the level of the ocean can have varied as much as this. Evidence of more recent elevation is afforded by the "raised beaches" which may be seen in many parts of the east coast of both islands.

On the 23rd January, 1855, a sudden elevation of the land took place in the neighbourhood of Wellington; the land rose about eight feet, sinking again afterwards three feet, so that the permanent rise was five feet; to the north and east of Wellington the rise is said to have been greater still—as much as nine feet on the west side of the Wairarapa valley. On the other hand, the west side of Cloudy Bay, north of Blenheim, was depressed to the extent of five feet. Naturally, such an extensive sudden movement of a large tract of country (4,600 square miles, it is estimated) caused a severe shaking of the earth's crust, or earthquake, the vibrations or waves of which travelled all over the colony; other shocks occurred for weeks afterwards, until, indeed,

this part of the earth's crust had resumed a more stable position.

Even greater sudden changes of level have occurred in other parts of the Western Pacific. During the earthquakes of 10th January and 14th February, 1878, the whole west side of the harbour at Port Resolution, Tanna, New Hebrides, rose twenty feet and twelve feet respectively; in April and June, 1888, there were other severe earthquakes, accompanied by still greater upheavals. The total vertical elevation noted by resident missionaries in ten years was probably not less than eighty feet.

It does not follow, however, that all changes in the land level are so sudden as to produce perceptible earthquakes. In all probability, by far the greater part of the elevation and subsidence that have taken place has been by imperceptible, gradual changes. It is well known that the west coast of Norway has been steadily rising for many hundreds of years at least, and very few earthquakes have occurred there; and in like manner, although New Zealand has not long been settled by Europeans, still, even during that short time, the observations of surveyors and others appear to show that a certain amount of slow elevation has taken place around Banks Peninsula, and probably at other parts of the east coast of the South Island.

It must not be assumed, either, that an earthquake is always the symptom of a change of level at the surface. Vibrations in the upper rocks may be produced by movements in the deeper portions of the crust which do not cause any immediate change at the surface; or, again, earthquakes may be caused

by the sudden discharges of heated steam and other matter that form the characteristic phenomena of a volcanic eruption. Generally speaking, earthquakes of the latter class are very limited in their range. At Rotorua, after the eruption of Tarawera in June, 1886, more than 110 shocks were counted in three days; but none of them were felt forty miles away, although the sound of the explosions and the volcanic dust travelled very much further than that. Again, small local shocks are very common in the volcanic district between Ruapehu and Lake Taupo; but few, if any, of the earthquakes recorded at Wanganui and Napier come from that region.

The chief characteristics of a sharp earthquake in New Zealand, as noted by an ordinary observer at a distance, say, of a hundred miles from the origin of the disturbance, are—

(1) Slight preliminary tremors, indefinite in character and direction, followed by a short pause;

(2) Continuous horizontal vibrations, in directions more or less confused, but more pronounced, especially at first, in one direction than in others;

(3) Other horizontal vibrations, often observed towards the end of the larger movements, in a direction at right angles to (2);

(4) Sometimes vertical vibrations, sharper, but smaller in range than the horizontal ones;

(5) More rarely—only in heavier shocks—long rolling waves passing along the surface of the ground like waves of the sea, though

more rapid and very much flatter than sea waves;

(6) The disturbance (more or less pronounced according to the intensity of the shock) of buildings, movable objects, or even of loose or unsupported portions of the ground;

(7) After-tremors gradually dying away;

(8) Sounds preceding or accompanying the vibrations, namely (*a*), those variously described by different observers as like distant thunder or the rumbling of heavy wagons passing along a road, and not heard at all by others (the "earth note"); (*b*), rustling, creaking, etc., obviously due to the disturbance of a large number of small objects on the earth's surface or of parts of buildings.

The facts noted by our supposed observer seem to show that, outside the area whence the disturbance proceeds, the phenomena of an earthquake consist of several series of vibrations, and of effects caused by the vibrations. This is confirmed by the records of seismographs, *i.e.*, instruments of various kinds employed for the exact observation of earthquake movements. The difference is that the instruments record movements that cannot be perceived by the senses, and record all the details with greater exactness. For instance, whereas an intelligent observer, not too far from the origin, may note three or even four different series of waves, Professor Omori, of Tokyo University, has shown that the seismographic record of a heavy earthquake from an origin even

thousands of miles away generally exhibits at least eight clearly distinguishable series of waves.

If a blow be given to a long-stretched string or a violin bow be drawn across it, the string will vibrate to and fro where it is struck, and the vibrations will travel along it throughout its entire length. Likewise, if a large mass of rock slide down a hillside, the portion of the earth's crust over which the rock slides will be put into a state of vibration; the vibrations will be communicated to adjacent portions of the crust, and may possibly be detected by means of instruments for some considerable distance. Such vibrations are called **transverse**, because each vibrating particle of the earth moves, as in the case of the string, **across** the line of propagation, that is, at right angles to the direction in which the vibratory motion travels. Transverse waves of vibrations are due to that elasticity of a rigid body in virtue of which it tends to recover its shape if disturbed (**elasticity of form**).

There are other vibrations which resemble the waves of sound. When an explosion of gunpowder occurs, the air surrounding the source or origin of the explosion is compressed; but, being elastic, it immediately expands, and compresses the air next to it, and so on, perhaps to a great distance. Each portion of air is alternately compressed and expanded for some time afterwards: and as the particles of air in this case evidently vibrate or move to and fro **along** the line of propagation, these vibrations are said to be **longitudinal** or **normal**. They are due to what is called **elasticity of volume**. We should expect waves of this kind to be formed in

the earth's crust whenever the rocks are suddenly compressed, or when the pressure upon them is suddenly relieved; they are accordingly sometimes called waves of compression. All the waves proceeding from a volcanic explosion would probably be normal waves unless there was a marked displacement of the rocks at the same time. It will therefore be important to ascertain whether most earthquakes are accompanied by both transverse and longitudinal vibrations.

The place at which the original motion giving rise to the earthquake occurs is called the **origin**, or **centrum**, or **focus**; the portion of the earth's surface directly above the origin is called the **epicentrum** or **epifocus**. The distance through which any vibrating particle of the earth's crust moves to and fro is called the **range** of the vibration; half the range, or the distance the particle moves from its mean position is called the **amplitude**.

The important facts to be remembered about earthquakes are:—(1) That their origins lie in general from five to twenty-five miles below the earth's surface; (2) that the rocks in which the origins are situated are very rigid and far more highly elastic than air or string, although the amplitude of the vibrations of the earth particles is much smaller; (3) that the effects observed in sharp or severe earthquakes, whether they are the disturbance of more or less movable objects upon the earth's surface, or of part of that surface itself, are really generally secondary effects. We say *generally*, because sometimes the disturbance of the earth's crust that gives rise to the earthquake may extend

to the surface, and there may open a chasm, or may cause a landslip or a rise or a fall of the ground on one side or other of the line of disturbance. Such, for instance, was actually the case in the Wellington earthquake of January, 1855, already mentioned, when the centrum or origin of the earthquake extended to the surface. In the Cheviot earthquake, of November, 1901, on the other hand, the origin was almost certainly at some depth, say ten miles, and at a distance of several miles to the west or west-north-west of Cheviot; but the road round the coast, that is, on the east side of Cheviot, was destroyed by landslips, which were just as much secondary effects of the shock as were the overturning of bottles on shelves, the downfall of walls and chimneys, and the displacement of houses from their foundations.

It is evident that the phenomena of the simplest earthquake may give rise to a large number of problems, many of which are by no means easy to solve. Before we can say we have an exact knowledge of the earthquake we must find the epicentrum, the depth of the actual origin below the epicentrum, the velocity with which the waves are propagated through the earth's crust, the *period* of the waves, or the time that each earth-particle takes to swing completely to and fro, the amplitude of the vibrations, the intensity of the shock, and other elements that it is not necessary to specify here. The first and third of these elements, and sometimes the second, may be ascertained for any earthquake that is perceptible to the senses if we have the exact time at which any particular phase of the shock was felt by observers at five or more different places.

Theoretically, the waves will travel with uniform speed in straight lines from the origin so long as they are passing through rock of the same texture; and actual observation, as will be seen presently, agrees so nearly with the theory that it must be assumed that for the greater part of their journey from the origin to any given place of observation, earthquake waves do travel through rocks that are homogeneous in character, or at all events through rocks that are nearly uniform as regards density, rigidity, and elasticity. In other words, the waves do not travel along the surface of the earth, but at depths great enough to ensure that for most of the way they escape what we may call the superficial accidents of the upper strata. Although the velocity of propagation remains uniform (except very near the origin), the rapidity of the vibrations decreases as we get farther away from the origin; and, since the disturbing effect of the vibrations decreases as the latter become slower, the intensity of the shock becomes less as the distance from the origin increases.

In the absence of instruments, the intensity of an earthquake is generally measured by its maximum effects, and to secure some approach to scientific accuracy in the use of such data, a scale called the Rossi-Forel scale (from the names of the two seismologists who devised it) has been in general use for some years. It is given below, together with the corresponding figures of an absolute scale, which denote the acceleration, in millimeters per second per second, which the earth-particles should have to produce the corresponding effect.

Rossi-Forel Scale of Intensity.	Absolute Scale.
I. Recorded by a single seismograph, or by several seismographs of the same model, but not by several seismographs of different kinds; the shock felt by an experienced observer.	20
II. Recorded by seismographs of different kinds; felt by a small number of persons at rest.	40
III. Felt by several persons at rest; strongly enough for the duration or the direction to be appreciable.	60
IV. Felt by persons in motion; disturbance of moveable objects, doors, windows, cracking of ceilings.	80
V. Felt generally by everyone: disturbance of furniture and ringing of some bells.	110
VI. General awakening of those asleep; general ringing of bells, oscillation of chandeliers, stopping of clocks; visible disturbance of trees and shrubs. Some startled persons leave their dwellings.	150
VII. Overthrow of movable objects, fall of plaster, ringing of church bells, general panic, without damage to buildings.	300
VIII. Fall of chimneys, cracks in the walls of buildings.	500
IX. Partial or total destruction of some buildings.	2000
X. Great disasters, ruins, disturbance of strata, fissures in the earth's crust, rock-falls from mountains.	?

Note.—The average intensity of the earthquakes recorded in New Zealand is 78 millimeters per second per second, or a little less than degree IV. on the scale.

If the effects are carefully observed by a large number of persons we may be able to mark on a map, say, first an area within which many ordinary chimneys were thrown down (VIII.); then outside that area, another in which chimneys were not overthrown, but crockery and bottles were overturned (VII.); then a third area in which the shock was sufficient to stop a number of clocks (VI.); and so on. The lines bounding such areas are called

isoseismal lines, or lines of equal earthquake intensity; obviously, then, the position and form of these lines will enable us to form a very good idea as to the position of the central region.

For instance, the Adelaide earthquake of the 10th May, 1897, was felt nearly all over south-east Australia, doing most damage at Beachport, Robe, and Kingston (Figure 1), especially at the first two

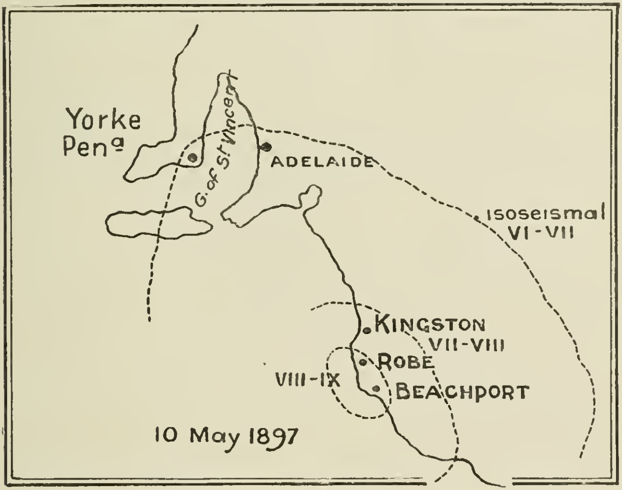


Fig. 1.

places, where it caused landslips, threw down chimneys, and injured walls of buildings. The origin of the earthquake would be beneath the sea-bed under the axis of the innermost isoseismal, that is, parallel to the best marked line of faults known in South Australia.

For the exact observation of earthquakes, however, instruments are necessary. Probably the instrument

that will interest New Zealand readers most is the Milne seismograph, two of which are installed in the colony, one at Christchurch, the other at Wellington. This seismograph acts as a horizontal pendulum; it consists of a light aluminium boom, resting against a pivot projecting from the lower part of an iron column, and held in nearly horizontal position by a

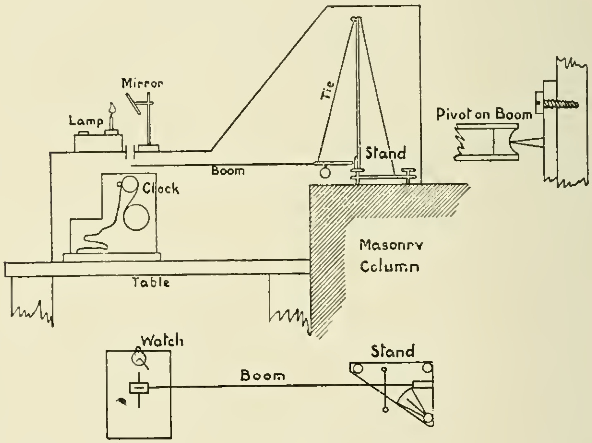


Fig. 2.

tie attached to the top of the column. The boom is weighted between the pivot and the tie, and the point of the pivot is slightly behind the point of suspension of the tie, so that the boom tends to occupy a steady position in the same way as a gate is made self-closing by putting the lower hinge behind the other. The section and plan of the instrument are shown in Figure 2. Light from a lamp is reflected through two slits at right angles—one in a small plate

attached to the end of the boom, and the other in the top of a dark box—so that a spot of light falls on a strip of bromide paper driven by clockwork within the box.

If the boom is disturbed suddenly in any way, the spot of light will pass to and fro across the strip of sensitive paper, which, when developed, will accordingly show not a straight line in the middle of the white band, as it does when the boom is steady, but

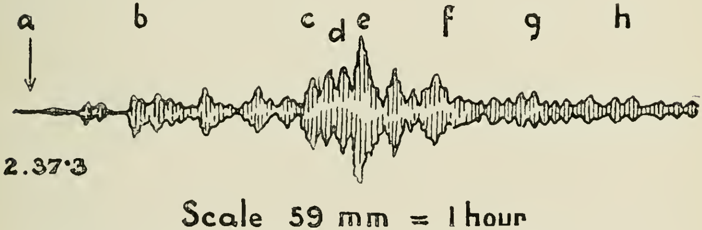


Fig. 3: Christchurch record of the great Guatemala earthquake of 19th April, 1902. (Greenwich mean civil time.)

a record of the oscillations of the boom. If the sudden disturbing cause be the vibrations of an earthquake, the photogram becomes a **seismogram**, or earthquake record.

On one of the two black bands at the edges of the paper (which also record the oscillations of the pendulum) are hour-marks produced by the minute hand of a watch, which is lengthened so as to pass once in each hour over the end of the fixed slit, thus eclipsing the light. Figures 3, 4, 5, 6, are the copies of four seismograms taken on the New Zealand instruments.

The small letters *a*, *b*,. . . .*h*, above Fig. 3 mark the beginning of the eight phases into which Professor

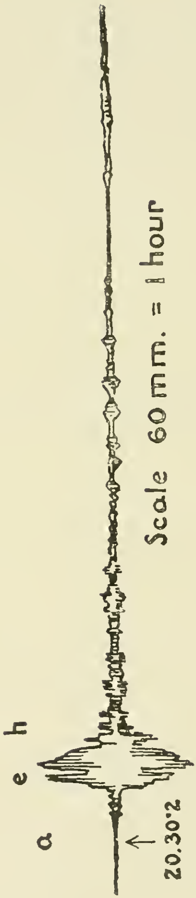


Fig. 4: Severe earthquake, 20th Nov., 1902, from origin probably near 21° S. lat., 172° W. long. N.E. of Tonga, Wellington record Greenwich mean civil time

Omori divides the waves. The most important of these are: *a*, the beginning of the preliminary tremors; *e*, the chief of the large waves; *h*, the last marked phase of the series; the position of the corresponding waves on Fig. 4 is marked by the letters *a*, *e*, *h*. In Figs 5 and 6 the downstroke on the margin shows the beginning of the preliminary tremors (*a*); the black line right across the seismogram gives the position of *c*, *d*, and *e*; the last phase (*h*) is shown in Fig. 5 by another downstroke, but cannot be distinguished in fig. 6.*

The Guatemala earthquake occurred at 2.26 at the origin, so that the preliminary tremors took 11.3 minutes to travel to Christchurch, a distance of 7164 miles; their **velocity of propagation** (or **transit**

* The fact that the interval between the arrival of the preliminary tremors and of the normal waves is very small when the origin is near, and increases with the distance from the origin is explained on the assumption that they start at or about the same time from the origin, and gradually become separated owing to the difference in their transit speeds

speed) was therefore 634 miles a minute, or 17 kilometers a second, or, taking the mean of the records from the stations all over the world, 15.6 km. per second.

The times of arrival of these waves (a) at the various seismological stations of the world appear to show that they travel round the earth, and not through its central portion, that is, along arcs and

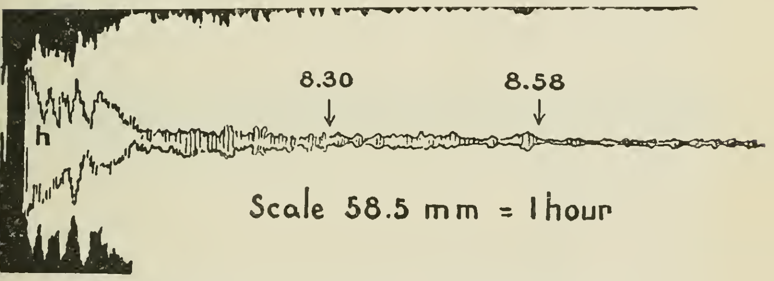


Fig. 5.: Wellington record of earthquake at Cheviot, N.Z., 16th November, 1901, beginning 7.47 a.m. New Zealand mean time.

not along chords. That is certainly true of the other waves ($b \ldots . h$).

The following table shows the transit-velocities of the chief waves of the four earthquakes just referred to in kilometers per second:—

Earthquake	a waves.	e waves.	h waves.
Guatemala	15·6	3·2	2·1
Tonga	13·0	3·3	2.2
Cheviot	12·4	3·5	2·3
East Coast	12·5	3·5	2.3

The high transit-speed of the a waves or preliminary tremors can be accounted for only on the assumptions, (1) that the vibrations originated in rocks under a maximum strain (it will be remarked

that the speed is greatest for the earthquake of greatest intensity); (2) that their path through the earth's crust was the path of maximum velocity, and therefore through the rocks of highest rigidity and elasticity.

The velocities of the *e* waves and *h* waves for various large earthquakes seem to vary very little, the average being 3.3 and 2.2 kilometers per second respectively. Now from theory, based upon the experimental determinations of the rigidity, elasticity, and density of various rocks, the speed of

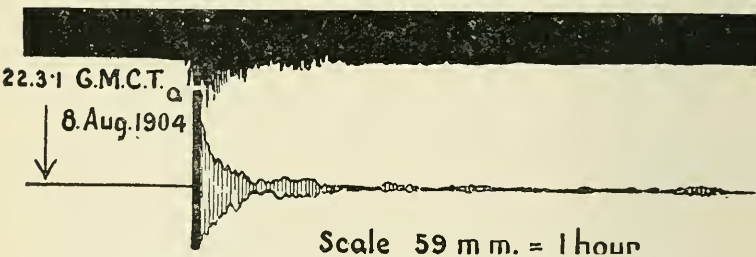


Fig. 9: East Coast earthquake on 9th August, 1904. (Wellington record.)

large normal or longitudinal vibrations through such rocks as hard granite is estimated to be between 3.1 and 3.95 km. per second, and the speed of transverse waves two-thirds of that of normal waves proceeding from the same origin at the same time and along the same path. It is therefore highly probable that *e* and *h* on the seismograms (of which those given are fair specimens) represent the chief normal and transverse waves, due, as we have seen, respectively to elasticity of volume and elasticity of form. Now, if the rocks were subjected to great pressure, as must be the case at a few miles

below the surface, the strain would be at a maximum just before yielding, and the consequent vibrations (*a*) would be small and rapid; as the rocks yielded to the strain, and were compressed, larger and slower vibrations (*c*) would be produced; distortion of the rocks would also generally take place, giving rise to transverse waves (*h*). The conditions would be satisfied if, under unequal vertical or lateral pressures in two adjoining portions of the earth's crust, there occurred bending or folding of the strata, accompanied or followed by fracture of the rocks such as gives rise to faults; there would be earthquakes, in fact, whenever any sudden adjustment took place, whether such adjustment were rapid tilting, the formation of a fracture, the rapid sliding of one rock face over another, or simply the crushing of rocks under great increase of pressure, or, what is most probable, several of these causes operating together.

Have we any evidence that these conditions have been satisfied in the case of New Zealand earthquakes? The great earthquake of 1855, to which reference has already been made, affords evidence that they have been satisfied at least in one instance. The origin, that is, the moving portion of the earth's crust, was at least as large as is indicated by the oval drawn on the map (Fig. 10, p. 243). The evidence is very clear that on the north-eastern side of this area the elevation was greatest; that it diminished towards the middle; that there was neither elevation nor depression in Porirua Harbour; and that on the south-west side of the focal area there was depression to at least five feet. This tilt,

or folding, as we may fairly call it, was also accompanied by fracture of the rocks, showing itself by surface rifts that ran for many miles north-east and south-west.

Again, reference to the map will show that the line joining Wellington and the epifocal area of the Cheviot earthquake of November, 1901, is nearly parallel to the general axis of New Zealand; a great rift (called by Mr. A. McKay, Government Geologist, the Clarence Fault) runs nearly in the same direction, and it is quite probable that it indicates the existence of a deep fault. The significance of this will be seen, if we turn to the Wellington seismogram of the Cheviot earthquake, (Fig. 5); it will be observed that the mean position of the central or zero line after the shock is nearer the lower edge of the paper, that is, nearer the west, than it was before the shock; this shows that the surface of the earth on which the column rests was tilted through an angle of about 1.3 seconds towards the west or north-west.* This tilting took place suddenly, but it is interesting to note that for some months before the earthquake a gradual lowering of the level on the west side had been taking place, and that a similar gradual movement has been going on up to the present time (September, 1904). The 1901 earthquake, therefore, gives us an example of tilting, or folding, in which the original fracture of the rocks did not apparently extend to the surface.

It is well known that strata originally more or less horizontal have been folded by forces acting on the earth's crust, the folds often appearing at the

* In the 1855 earthquake the angle of tilt could not have been less than 4 seconds, and may have been as much as 10 seconds.

surface so as to form wrinkles or mountain ranges and valleys. Several possible causes of this folding may be assigned. Two of the most important are:

Fig. 7.

I., the gradual cooling of the earth; II., the loading of the ocean bed through denudation of the land surface.

I.—**Cooling of the Earth.**—Observations in deep mines show that the temperature of the earth increases with the depth below the surface; and at the depth of a few miles the temperature must be very high, as the heat is sufficient to bring what are on that account called **igneous** rocks to the melting point. The average rate of increase near the surface is known to be about 1° Fahrenheit for every 51 feet of descent; but that rate cannot continue to all depths, for at the depth of 200 to 400 miles the temperature would be equal to the temperature of the sun's surface. The probability is that the rate of increase of temperature diminishes with the depth, and that, about 30 miles below the surface,

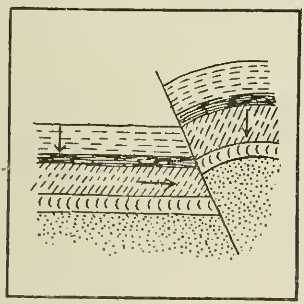


Fig. 8.

the rocks are in a state of potential liquidity, that is, they are so hot that they would become liquid were it not for the pressure to which they are subjected. At some depth below that—100 miles below the surface, according to Lord Kelvin, but much less according to others—the whole mass is, whether liquid or solid, probably very nearly at the proper melting temperature for the pressure at each depth; so that the state of the matter there cannot affect the temperature in the strata above. These upper strata form what is probably called the **crust** or **lithosphere**, the inner portion being the **nucleus** or **centrosphere.** Heat will continually pass from the interior to the surface, where it will be dissipated into space. The temperature of the rocks near the surface, being the temperature of space modified by the heat from the sun's rays, is practically constant; so that those rocks will not contract. All other layers of the crust will cool and contract at rates varying with the depth. The volume of the layers in which cooling is greatest will, after contraction, be too small to fill the space into which the layers fall, and they will therefore be pressed out by the weight of the rocks above them. But the upper strata, which cool less quickly, will be too large to fill the space into which they fall, and their surface will accordingly be crumpled.

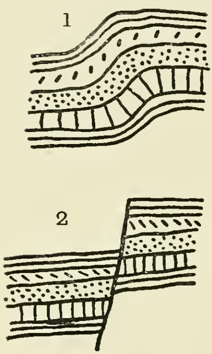
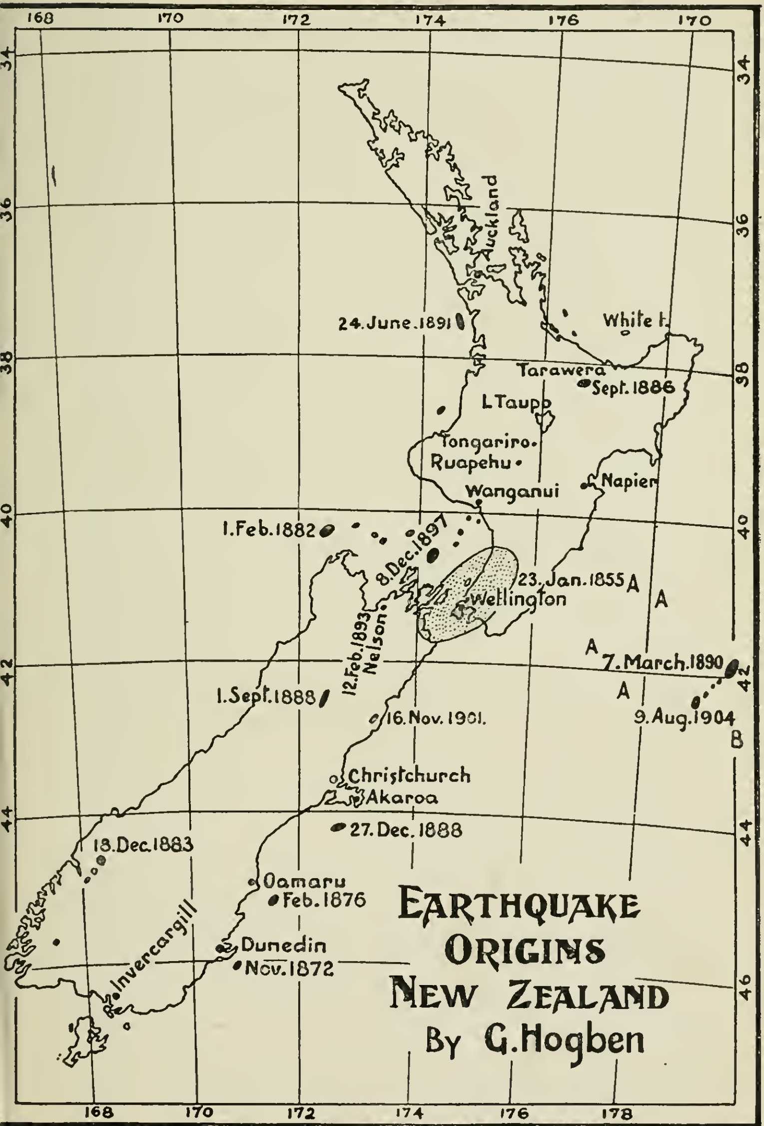


Fig. 9.



EARTHQUAKE ORIGINS NEW ZEALAND
By G. Hogben
Auckland
White I.
24. June. 1891
Tarawera
Sept. 1886
L. Taupo
Tongariro
Ruapehu
Napier
Wanganui
1. Feb. 1882
8. Dec. 1897
23. Jan. 1855
Wellington
Nelson
12. Feb. 1893
7. March. 1890
9. Aug. 1904
1. Sept. 1888
16. Nov. 1901.
Christchurch
Akaroa
27. Dec. 1888
18. Dec. 1883
Oamaru
Feb. 1876
Invercargill
Dunedin
Nov. 1872

Fig 10.

The process is well illustrated by an experiment known as Le Favre's experiment (see Fig 7). A mass of plastic clay was placed upon a stout caoutchouc band, which had been stretched; the band was then allowed to contract slowly. The effect was to produce the series of elevations and troughs (**anticlinal** and **synclinal** folds) shown in the figure. The folding or crumpling, both in the experiment and in nature, is determined partly by previously existing lines of weakness, partly by inequality of vertical pressures due to differences of texture and density in the upper layers. Unequal **vertical** pressures on adjoining portions of the earth's crust will cause unequal **lateral** pressures, and a tendency for the rocks to "creep" or move horizontally in order to repack themselves in a more stable condition. This **lateral thrust**, again, may produce fractures, reversed faults, and elevation of those strata which are less dense or subject to a smaller vertical pressure. Fig. 8 is a diagrammatic representation of the formation of a **reversed** fault; the arrows indicate the directions in which the rocks tend to move.

Obviously, earthquakes will occur whenever any of these movements are sudden in character.

Increase of vertical pressure might also cause, under some conditions, an intrusion of the deeper and hotter rocks from below through weaker portions of the crust—which would again be a cause of seismic, and perhaps of volcanic, disturbance. It is probably only in this sense that the definition of an earthquake as an ineffectual attempt to establish a volcano can be accepted.

II. "**Loading.**"—Another cause of folding is the

transference of material from the land surface to the bottom of the sea by the agency of rivers; the pressure on the strata underlying the land will be thereby relieved, and the pressure on the floor of the ocean will be increased. There will thus be a folding of the strata near the junction of the land surface and the ocean-bed, which may continue until

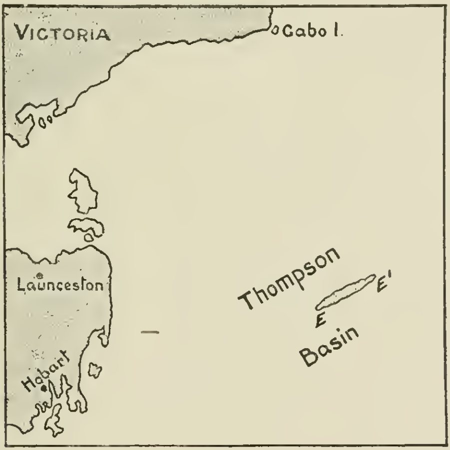


Fig 11.

fracture takes place, the strata on the land side moving up, and those on the ocean side moving down. The displacement of the strata will form a normal fault. (Fig 9). After the fracture, the two faces of the strata will continue to slip and to slide one over the other so as to increase the amount of displacement. The slipping may go on very gradually, but from time to time sudden slips will probably occur, and these will produce earthquakes. Moreover, as in the case of folding due to cooling, the differences of vertical pressure will induce lateral thrusts,

tending to cause "reversed faults"; but in this case the tendency will be most marked at a considerable depth below the surface, where the pressures are greatest. Subsequent action may raise the deeper rocks, and reveal faulting that has occurred ages ago.

The facts in regard to the folding of the crust are not, of course, so simple as they have been stated here; but, generally speaking, all the movements resulting from unequal vertical and lateral pressures between the rocks may be summed up in the term "**repacking.**"

The evidence already given is perhaps not sufficient to establish completely the theory that earthquakes generally are connected with fault-movements and similar processes of repacking of the strata. But it makes that theory highly probable; it must be remembered that the value of such evidence necessarily depends upon its cumulative weight, and it would be too tedious to give a large mass of evidence of this kind here. Moreover, our knowledge of the position of the geological faults in New Zealand is too limited as yet to prove the theory from New Zealand examples. Dr. Charles Davison, an able British seismologist, has shown in a very careful series of investigations the connection between many British and European earthquakes and known lines of fault.

A study of the map of the seismic origins in the New Zealand region (Fig. 10) will strengthen the evidence already given in favour of the theory. Before considering these, it may be as well to name the nearest known origin outside the New Zealand region.

On the 27th January, 1892, an earthquake of the intensity VII.-VIII. (Rossi-Forel scale)—probably X. near the origin—was felt over almost the whole of Tasmania, in Victoria, as far west as Melbourne, and in the south-east part of New South Wales, **but not in New Zealand**. The epicentrum (marked E E′ on Fig. 11) was about 353 miles east of Launceston; it lies on the western slope of the Thompson Basin, the great trough in the Tasman Sea. The same region contains the origins of at least three well-marked Tasmanian earthquakes, namely, those of 13th July and 19th September, 1884, and 13th May, 1885.

From April, 1883, to December, 1886, 2540 shocks were recorded by Captain Shortt, R.N., of Hobart, and his assistants, nearly all being very slight; probably the earthquakes just named above were due to the principal movements, and the numerous smaller after-shocks or tremors indicated the slight adjustments of the Tasmanian land-mass. We have yet to discover what connection, if any, there is between these and other movements in or near Australia and Oceania, and those of New Zealand. Most of the evidence available seems to point to the hypothesis of a general elevation of the floor of the Western Pacific; but the evidence so far is very meagre and disconnected.

The **origins** of the New Zealand seismic region will be seen to arrange themselves in groups as follows:—

Group I.—Earthquakes felt most strongly on south-east coast of North Island; epicentra form a strip 180 miles from the coast, parallel to the axis of New Zealand, and to axis of folding of older Cainozoic rocks in Hawke's Bay. Chief shocks, 17th August, 1868, 7th March, 1890, 23rd and 29th July, 1904, 9th August, 1904 (Intensity IX. on R.F. scale), 8th September; prob. 23rd February, 1863 (IX., R.-F.); etc.

According to Captain F. W. Hutton, F.R.S., the geological evidence shows that New Zealand rose considerably in the older Pliocene period, and was then probably joined to the Chatham Islands. At a later period subsidence occurred, followed again by elevation in the Pleistocene period. with oscillations of level since. The seismic origins of this group are at the foot of a sloping submarine plateau, about 200 miles wide (marked B on the map), which culminates to the east-south-east in the Chatham Islands; this elevation is separated from the New Zealand coast by a trough from 1,000 to 2,000 fathoms in depth, which is widest and deepest at A A, that is between these origins and the mainland.

Group II.: viz.:—

(a) South-east of Otago Peninsula. Shocks: 20th November, 1872, etc.

(b) A strip south-east of Oamaru. Shocks: February, 1876; April, 1876, etc.

(c) Many short and jerky, but generally harmless, quakes felt in Christchurch, Banks Peninsula, and Mid Canterbury. Chief shocks: 31st August, 1870, 27th December, 1888 (VII. R.-F.), etc. Focus of 1888 shock, 16 miles long from W.S.W. to E.N.E., 24 to 25 miles below surface, being deepest ascertained origin in New Zealand region.

These origins form a line parallel to the general axis of the land. It is quite possible that the loading of the sea floor by the detritus brought down by the rivers is a contributing cause of the earthquakes of this group.

Group III.: Wellington earthquakes of January, 1855, and Cheviot earthquakes of November, 1901.

Remark has already been made as to a possible relation between these origins. The great earthquakes of October, 1848, probably came from the

same region as those of January, 1855; the chief shocks of both series did extensive damage to property, and caused the formation of large rifts in the earth's surface; they are the only seismic disturbances since the settlement of the Colony that can be assigned to degree X. on the Rossi-Forel scale.

Group IV.: (a) Region about 25 to 30 miles in length and, say, 10 miles or less in width, running nearly N.N.E. from middle of Lake Sumner, about 20 miles below the surface, whence proceed most of the severer shocks felt from Christchurch to the Amuri, and a large number of minor shocks. Chief earthquakes: 1st February, 1868; 27th August to 1st September, 1871; 14th September and 21st October, 1878; 11th April, 1884; 5th December, 1881 (VIII., R.-F.), when Christchurch Cathedral spire was slightly injured; 1st September, 1888 (IX., R.-F.), when upper part of same spire fell, and still more severe damage was done in the Amuri district.

(b) A small shallow origin not more than five to ten miles below the surface, a few miles south of Nelson. Earthquake: 12th February, 1893 (VIII. to IX., R.-F.); chimneys thrown down and buildings injured.

(c) Origin in Cook Strait, N.N.E. of Stephen Island, about ten miles wide, and apparently traceable with few interruptions nearly to mouth of Wanganui River; depth, 15 miles or more. More than half the earthquakes recorded in New Zealand belong to this region; earthquake of 8th December, 1897 (VIII. to IX., R.-F.), and other severer ones come from S.S.W. end.

(d) An origin near Mount Tarawera, with a large number of moderate or slight shocks, most, but not all, volcanic and local in character—*e.g.*, those of September, 1866, and those of June, 1886, which accompanied and followed the well-known eruption of Mount Tarawera.

These origins of Group IV., (a), (b), (c), (d), are nearly in a straight line on the map; on or near the same line are the origins of earthquakes felt in the Southern Lake District (15th December, 1883, etc.),

the volcanoes Ruapehu, Ngauruhoe, Tongariro, Tarawera, and White Island. It is evident that this line, which like the rest is parallel, or nearly so, to the general axis, is a line of weakness or of unstable equilibrium. Hence the adjusting movements that have caused earthquakes may have, from time to time, relieved the pressure of the rocks that restrained overheated steam and other volcanic agents from bursting out, and so may have led to volcanic eruptions; just as the series of earthquakes in Guatemala and in the Caribbean Sea in April and May, 1902, were the signs of movements in the great folds of that part of the earth's crust, in the course of which, the pressure in the Antillean Ridge being relieved, the volcanic forces below Mount Pelée in Martinique, and Mount Souffrière in St. Vincent caused the disastrous eruptions of that year.

Group V.: Off the coast near Raglan and Kawhia. Chief shock: 24th June, 1891 (VII.-VIII., R.-F.). The line joining this origin to that of the earthquake of 1st February, 1882, is parallel to the other lines of origins (Groups I. to IV.); but we have no data to establish any connection between them.

Chapter XII.—CLIMATE.

Conditions affecting Climate.—Directly or indirectly all variations in temperature, rainfall, and wind are due to the sun's influence. In every case other influences modify the effect produced by the sun. These influences are often purely local in their nature, and thus it is that every small area has some more or less important peculiarities in climatic

character that are not shared by the neighbouring districts.

The temperature of any locality depends mainly upon its **latitude**, or in other words, upon the direction in which the sun's rays strike the ground. The higher the sun in the heavens, the greater its effect in heating the earth's surface, and ultimately the air in contact with this surface. The direct action of the sun is nearly always modified to a greater or less extent by many local conditions. The frequent presence of clouds, the proximity of water areas or of lofty mountains, the direction of the prevailing wind, the elevation above the sea level, the direction of ocean currents in the nearest ocean must all be considered before any reliable conclusion can be arrived at as to the probable temperature of any locality.

Any district bordered by the **ocean** will have a mild and slightly varying temperature. Frequent **cloudy days** reduce the temperature. When lofty **mountains** are near at hand, the climate is cooled by the mere presence of masses of ice and snow; from the moist winds that blow against them clouds are formed that screen the land from the sun's rays. An elevated tract is cold because the air above it does not obstruct the heat rays that pass from its surface. As soon as the sun sets, the heat the rocks have received from it during the day streams away, and soon an intense cold results. The **moisture** that the air contains in the shape of invisible steam is the substance that, more than any other, prevents the passage of heat rays to or from the earth. There is little of this steam or water-vapour in the upper

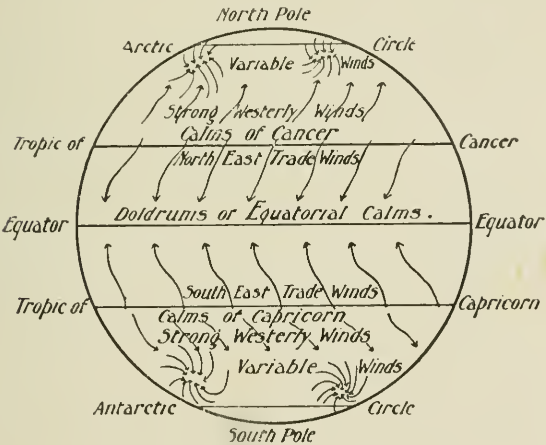
portions of the atmosphere. In some portions of the earth's surface, where the land is desiccated and desert, there is but little obstruction to the passage of heat rays, for the air contains little water-vapour, and in these places extremes of temperature are experienced.

Wind blowing from the ocean has the temperature of the oceanic water, and if warm **currents** are flowing along the shore, the winds will be warm, but if the oceanic currents flow from polar regions, the winds from their surface will be cold and will cool the land on which they blow.

The **relation between the sun and rainfall** is not so apparent as that of temperature. Sunshine is the ultimate cause of rain, for the sun's heat is necessary to evaporate the water that forms the clouds. Afterwards the sun's influence is not of first-rate importance in precipitating water from the clouds, or in distributing the rainfall. When the moisture-bearing air, in the form of wind, comes into contact with any cold surface, clouds are formed, and if the cooling is great enough, rain will be condensed from them. The cooling may result if the wind strikes a mountain range and rises up its flanks. Contact with another colder body of air may produce the cooling as effectually as other means. It is evident that the proximity of some oceanic area is necessary in order that any country should have an abundant rainfall, otherwise the sun's rays will be unable to evaporate the water that is required for the formation of clouds; but in order that this water-vapour should be converted into clouds and rain, it must be cooled. This is effectually done by actual contact with cold

air or cold land surfaces, but a sudden change in the direction of the wind may be as potent a cause.

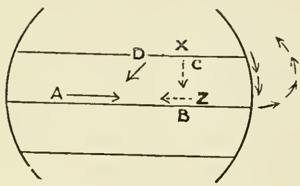
Prevalent winds of the world.—The wind to an ordinary observer appears to be the most unstable and variable of all those meteorological factors that go to make up a climate. There are, however, certain broad tracts of the earth's surface where winds more



Prevalent Winds of the World.

or less constant in direction, and even in force, are continually experienced. These regions in particular are those on each side of the equator where the trade winds blow, and the regions bordering these to the north and south, where the westerlies blow more or less constantly. Calm zones extend round the earth between the two trade wind regions and between the trades and westerlies. The first is the region of **doldrums** and the other two the **calms of Capricorn** and **Cancer**.

These regular winds are directly caused by the effect of the sun's heat. When the sun shines on a land area, it rapidly heats the land and the air in contact with it. The air is lighter when heated, so at once rises, and flows away as an upper current. More especially is this the case in the equatorial regions, both land and sea, for the sun's heat is particularly great, The hot air flows away north and south as an upper current, and on the earth's surface air currents flow south and north to take its place. The circumference of the earth is greater at the equator than to the north or south of that line, and as all parts of the earth complete one rotation in the same time, any point on the equator is always moving more rapidly than a point north or south of it. The air at any latitude has the velocity of the earth at that latitude. When air flows from the south or north to the equator, it has only the rotational velocity of the surface of the earth at the latitude from which it flows. This velocity is less than that of the equator, so the air lags behind. The earth rotates from west to east, and the transferred air, travelling less slowly than the earth's surface, would appear to flow from east to west, but it has also the velocity with which it flows towards the equator. The combined effect of these two velocities makes the flow of air or wind appear to blow from the north-



A. Direction of earth's rotation.
B. Direction of air flow if air suddenly transferred from X to Z.
C. Direction of air flow towards equator.
D. Combined effect of C and B.

east in the northern and from the south-east in the southern hemisphere in the trade regions at variable distances north and south of the equator.

The air that rises at the equator reaches the earth's surface again in the temperate regions, and has a higher velocity than the earth's surface in those latitudes, and thus forms a broad zone of prevailing westerly winds. It returns to the earth's surface because it becomes cooled, and increases in density after it has risen. Its velocity is higher because it has the west to east surface velocity of the earth's equatorial region, which is greater than the west to east surface velocity of the temperate zones; the effect of this is the production of a westerly wind.

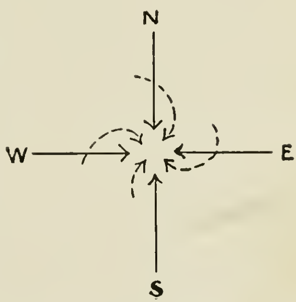


Diagram of wind directions in a cyclone. The arrows mark the direction of flow of air to fill the cyclone. The dotted arrows mark the deflected currents caused by the earth's rotation.

As the westerlies march onwards, areas of low pressure arise. These are chiefly due to the heating and expansion of the air in certain, but varying places. This heated air rises, and in the higher regions flows outwards, while air flows inwards on the earth's surface. Air flowing southward is deflected to the east in the southern hemisphere, for it is moving from a region of relatively high to a region of relatively low surface velocity. Similarly a current flowing north is deflected to the west. East and west currents are also affected. Thus the air

flowing in to a low pressure area will tend to move in a spiral, and the direction of the spiral is that in which the hands of a watch move. These areas are **cyclones.** **Anticyclones** are areas of high pressure. From these the winds flow outwards, but in the same spiral manner.

Cyclones are associated with violent, stormy, and usually wet weather; anticyclones with settled light winds and dry weather.

Thunder and lightning are frequent in regions where evaporation is rapid, for the electricity, to whose action they are due, is generated during the quick evaporation of water.

Climate of New Zealand.

*__Temperature.__—The most marked feature in regard to the general bearings of the New Zealand climate is the entire absence in all the low lying parts of the land of extremes of heat and cold. The land stretches over 13 degrees of latitude and 630 miles separate Dunedin from Auckland, the two extreme stations where daily observations of temperature are made. The difference in mean annual temperature between these two stations is 8.7°, for the average for 38 years in Auckland is 58.8°, and in Dunedin 50.1. In the northern hemisphere the same difference exists between the mean annual temperatures of Marseilles and Belfast.

The slight **variation** in temperature throughout the year in New Zealand is particularly remarkable. This is shown clearly in the monthly averages. In

* Note.—All the statements of temperature refer to readings of the Fahrenheit scale.

Auckland, the coldest month, July, has an average temperature of 51°, and the hottest month, December, an average of 65.5°. The variation in Dunedin is nearly as small. August, the coldest month, has an average of 40.5°, and February, the hottest month, 57.2°. In London, the hottest is 63°, the coldest 38°. The extreme range of temperature during the year in Auckland is 40°, and in Dunedin, 53°. In London, the extreme range is 59°. The average difference between the temperatures of day and night in Auckland is 10.7°, and in Dunedin, 13.4°. In London the difference is 15°. Similar results are obtained when the temperatures recorded at all other New Zealand stations are compared, though the very marked uniformity is not everywhere quite so conspicuous. This is particularly noticeable in towns situated at some distance from the sea coast, though unfortunately there is not in any case a very complete series of records that can be quoted. The insularity of New Zealand is the cause of the slightness of the seasonal variations of temperature that are experienced. The coast line of New Zealand is of great length, and no portion of the land is far removed from the ocean. Thus the air temperature has the characteristics impressed upon it by the ocean rather than those due to any land influence acting upon it. It is one of the most remarkable properties of water that it cools slowly. This is due to the two facts, that it must gain or lose more heat than most other substances in order to raise or lower its temperature a given amount, and that its surface gives off heat slowly. These properties cause the water to retain its heat to a great extent during the night, so the

air in contact with it remains warm, and keeps the temperature relatively high in those land districts near the sea. The smaller any island is the more completely does its temperature show the effect due to the oceanic waters that bathe its shores. Though New Zealand is comparatively large, its long narrow form allows the effect of the surrounding ocean to be more pronounced than would be the case if it were broader and shorter.

In the more inland districts of the dominion the ocean has naturally less importance in affecting the temperature. In some of the Central Otago districts snow may lie on the ground for some weeks in midwinter, and the temperature at night time may very occasionally fall to 15° below zero, while in summer its temperature rises to an average of at least 65°. This great contrast to the general New Zealand climate is the result of its inland position and the dryness of the air, which does not obstruct the heat of the sun's rays from reaching the earth, nor does it prevent the heat rays from leaving the earth during the cold of winter. The elevated position of the Central Otago district (about 1,000 feet) has also a considerable effect upon the peculiarities of its climate, for it still further diminishes the obstruction that the heat rays encounter.

The variations in the temperature of much of the east coast of New Zealand depends on the direction of the wind. The north-west winds, for reasons that will be more particularly mentioned afterwards, are distinctly warm, while those from the south-west are cold. The passage of cyclonic disturbances causes

a sudden change from N.W. to S.W. in the wind directions, and with this change there is as sudden a reduction in the air temperature. Even in the middle of the day, if such a change of wind takes place, the temperature may fall 30° within an hour's time.

One of the most marked characters of all land areas in the far south is the low summer temperature, and the not infrequent occurrences of cold storms almost as fierce as those of the winter season. The climate of New Zealand partakes of this character to some extent. Its southern portions in particular may during any one of the summer months be suddenly invaded by a cold storm, and snow has been known to fall even in midsummer, though it is not usual for this to happen even in winter storms.

The diagram adjoining on page 264 may serve to show the peculiar nature of the New Zealand climate. The curves of temperature for the four chief centres of population are seen to undergo very slight variations, less even than that for Greenwich, though the climate there is of the insular type as in New Zealand. For comparison is added the curve for Barnaul in Siberia—a town subjected to the great extremes that are particularly characteristic of a continental climate, where the tempering influence of the ocean is not felt.

Oceanic currents are partly responsible for the comparatively low temperature of New Zealand, when the temperature of other countries in the same latitude is considered. The currents that wash our coasts are generated by the westerly winds that course round the world in the latitude of New Zealand. Barred by the western coast of Australia,

these slow currents flow past its southern shores, and pass north-east to the east of New Zealand. This cold southern water flows north, but it gradually sinks beneath the warmer waters of the Central Pacific. Its cold surface keeps the winds that blow from it cold, and this, more than any other cause, makes the average temperature of New Zealand towns so low when compared with those of other towns in the same latitude, *e.g.*, Auckland 60°, Algiers 70°; Dunedin 52°, Bordeaux 56°.

The West Coast is washed by a current that flows across the Tasman Sea from the Australian Coast. The west coast is thus warmer than the east.

Hokitika, 54.3 throughout the year; Christchurch has a mean temperature of 52.2; New Plymouth, 60.5; Auckland, 58.6; these were the figures for 1903. The high temperature of New Plymouth is partly due to its sheltered position with regard to southerly winds.

Rainfall.

There are but very few portions of New Zealand that suffer from a deficient rainfall. There are more districts where the heavy rainfall interferes with the activities of the settlers, and prevents them from following agricultural or even pastoral occupations. For such a small country the variation in the amount of rainfall is very great.

The smallest average that has been recorded is that for Clyde, 14 inches per annum; the highest recorded is for Puysegur Point, where the average was 228 inches for six years previous to 1900. In the next

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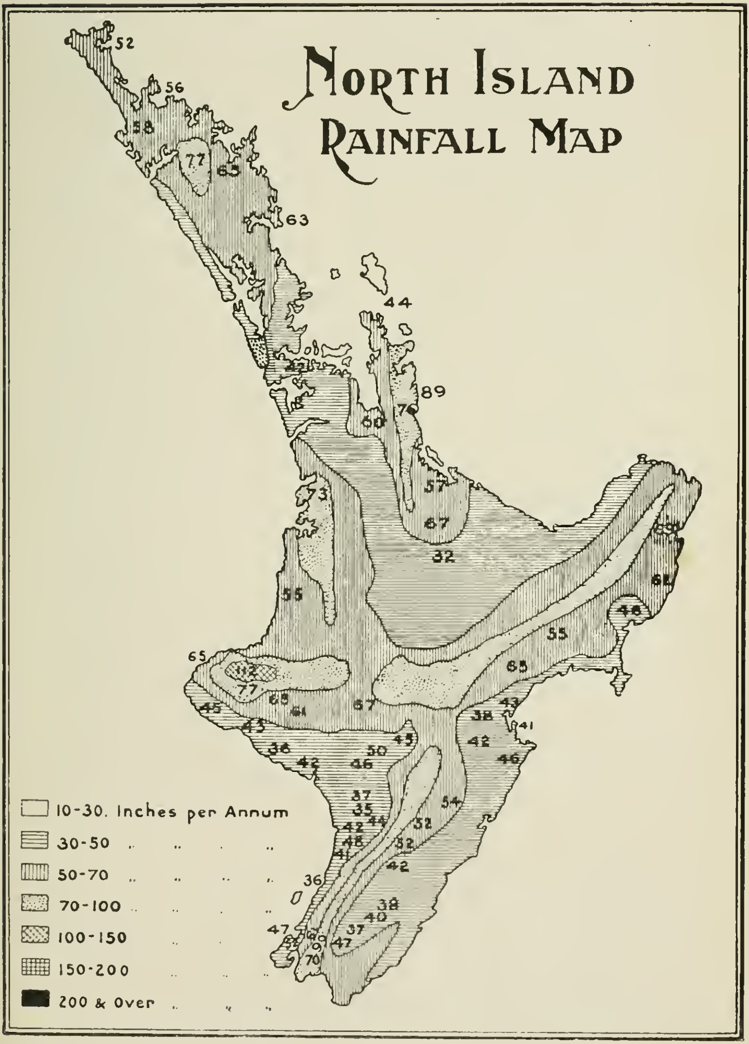
For diagram showing comparison of annual rainfall at chief centres of population, see page 334.


North Island
Rainfall Map
10-30. Inches per Annum
30-50 .. ..
50-70 .. ..
70-100 .. ..
100-150 .. .
150-200 .. .. ..
200 & Over .. " "
52
56
58
77
65
63
44
89
76
60
57
67
32
73
55
69
62
48
55
65
112
77
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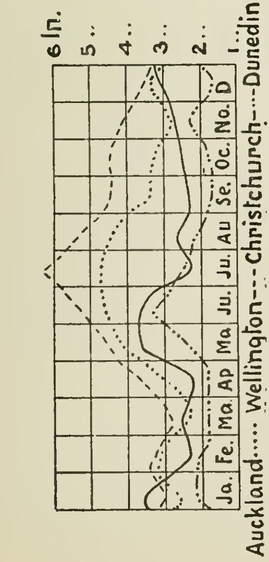
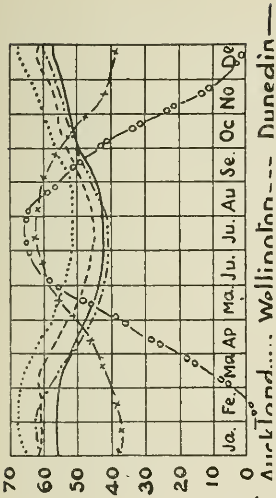
70

seven years the average was 106. Yet these places are only 150 miles apart. Observations have so far been chiefly restricted to portions of the country that have been closely settled, and these in the North Island are for the most part coastal regions, and in the South Island localities near the east coast. Isolated measurements have been made in other places, and the map on page 265 is based on these, combined with results based on local knowledge and on the distribution of those land forms that have most influence on the rainfall. In the North Island there is copious rainfall in the north of Auckland. In all places it is more than 50 inches, and occasionally more than 70. This rainfall is caused by the hilly country which is encountered by the moist westerly winds. Where these strike the hills, they are forced to rise, and their temperature is lowered. They can no longer retain all the moisture with which they were charged, and much of it is precipitated as rain. Round Auckland and over much of the land to the south, there is a smaller rainfall. There are few stations in this area where observations have been made, but the rainfall is probably not heavy, for the westerly winds have to some extent been robbed of their moisture by the high hills of Pirongia and Kerioi before they reach the Waikato country.

All the west coast has a sufficient rainfall, though it is most abundant where the land is highest, for near Wanganui, where the hills are lower, the rainfall rises little above thirty inches over all that portion of the coastal plain. Near Mount Egmont it is very high, and at two stations to the east of it, it reaches over 100 inches, and at the mountain house at an





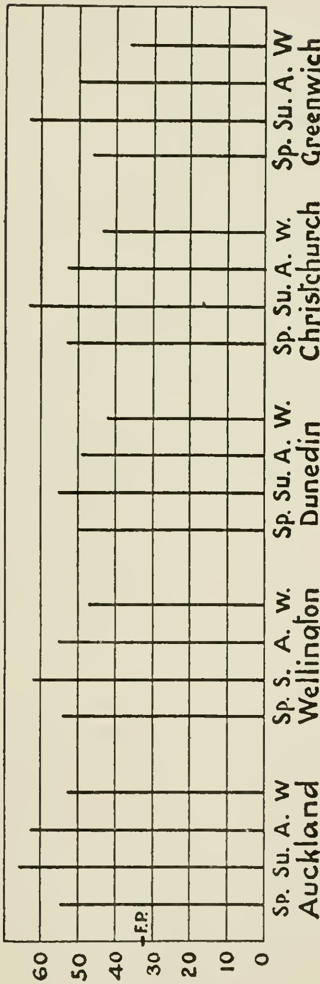


Diagram showing the average temperatures during the four Seasons

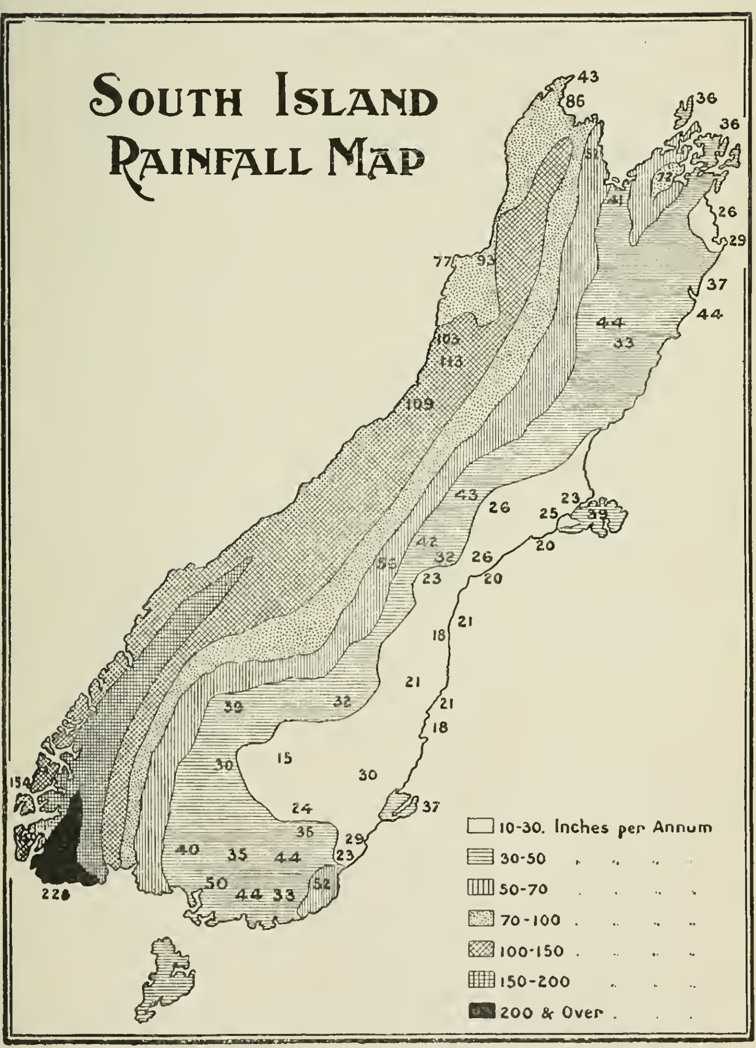
elevation of 3140 feet on the northern slopes 287 inches fell in the year 1910.

Though recording stations are scanty, it is safe to say that throughout the backbone of the island the rainfall is more than 70 inches. The only actual high level stations are the Summit and Wainuiomata, where the fall is 90 and 71 inches respectively. Further east all the stations record less than 70 inches, and there is a broad strip near the coast, where the rainfall is under 50 inches.

Coromandel Peninsula is another wet district, for the land is high, and the westerly winds have been but little robbed of their moisture by the low lands of the Auckland isthmus.

The South Island has a much wider range of variation, for the high land that everywhere borders the ocean on the west causes almost all the moisture to fall as rain, so with the exception of a few small patches in the N.W., the fall is greater than 100 inches everywhere on the western side. Again, there are few stations where observations are made, and they are on the coast, where the fall is probably far less than a few miles inland, where the effect of the high country is more pronounced. The average of 154 at Dusky Sound and 228 at Puysegur Point would probably be equalled or even exceeded at many points in the south-west fiords.

There is but little guide for the demarcation of areas of smaller rainfall to the east until the small amount of between 30 and 50 is reached. This is the fall over a wide strip extending throughout the length of the island. It includes much of the better


SOUTH ISLAND
RAINFALL MAP
10-30. Inches per Annum
30-50
50-70
70-100
100-150
150-200
200 & Over
43
86
36
36
26
29
37
44
77
93
44
33
103
109
43
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154
228

class of pastoral country of the east side. On all the central portions of this coast there is much country with a rainfall of less than 30 inches. The country is low-lying, and the prevailing westerly winds are completely dried by their passage over a great width of high mountainous country. There are three wetter districts on the coast. South of the Nuggets there is a heavy rainfall. The Otago and the Banks Peninsulas have more than 35 inches annually, while at the head of Pelorus Sound more than 70 inches fall. In all these cases the greater rainfall must be attributed to the high land in the neighbourhood.

The influence of rainfall on the **vegetation** is very marked. In almost all places where it is less than 40 inches, the land has few forest areas, but is covered with yellow tussock grass. Where the rainfall is higher, forest covers the surface. On the eastern slopes, where the rainfall is not very high, but the variation in temperature great, beech (Fagus) forests are most frequent; but on the western, where the rainfall is high and temperature is more constant, the luxuriant, matted, mixed forest that is so very characteristic of New Zealand is found.

The distribution of rainfall has had much influence upon the **progress of settlement**. At first, timber and flax were the main requisites, so settlements were formed in some of the most accessible of the wetter districts, especially to the north of Auckland, where good harbours provided easy access to the magnificent timber forests.

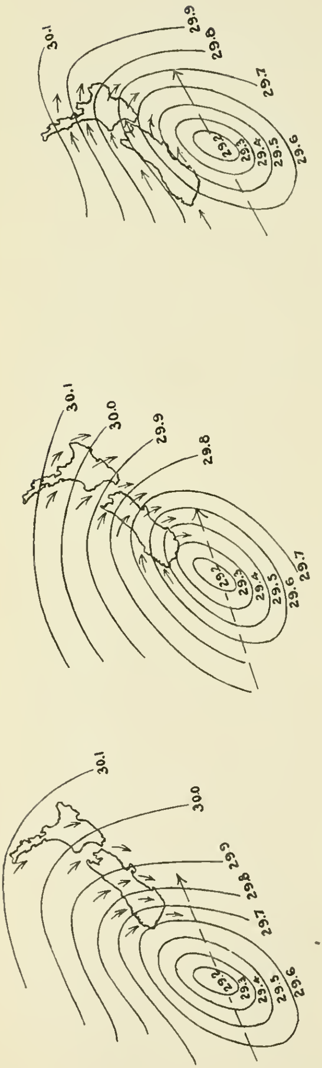
Later on, pastoral occupations began, and the Wairarapa and Wanganui districts were occupied by

settlers, spreading out from the headquarters at Wellington. Pastoral settlements at Canterbury, and Otago afterwards, were still more rapidly developed, and the well-grassed surfaces of the eastern portion of these provinces were soon covered with the flocks and herds of the settlers. Settlement spread westward and even to the West Coast, but only when gold had been discovered there. Even now settlement on the West Coast is slight, for much expense is incurred in felling the dense forest, and difficulty is experienced in burning the fallen timber off the land. Even when the fallen timber is removed, the pasture does not grow so readily as in most places in the dominion.

In the south, especially on the high land, some of the winter fall is in the form of **snow**, and though it seldom lies more than a few weeks, even this may cause much loss to the settlers who own the up-country runs. Snow falls in many places in the North Island during severe winter storms, though it does not lie more than a few days, except on the mountain tops.

Winds.

New Zealand lies in the "roaring forties," latitudes that are swept year in and year out by a constant succession of cyclones, travelling from west to east. The sudden variations in weather are due to the movement of these **cyclones**, which always have different weather characters in their different portions. The cyclones that visit New Zealand generally move from W.S.W. to E.N.E. at a rate of 200 miles or more every 24 hours, and pass to the



Diagrams showing direction of wind caused by three different positions of an advancing cyclone. The arrows mark the direction of the wind; the dotted arrows show the cyclone track. I. Cyclone centre to W.; wind N.E. on the east coast and N.W. on the west. II. Cyclone centre to S.; wind N.W. on east coast and S.W. on west coast. III. Cyclone to E.; wind S.W. everywhere, except on east side of North Island.

south of Stewart Island. On weather maps lines are drawn connecting all those places that at any particular time have the same barometric pressure. These lines are **isobars,** and their position changes hourly. Near a cyclone the isobars form concentric curves, often of an irregular nature, extending round the centre of low pressure.

The approach of a cyclone disturbance is marked by a gradual fall of the barometer, and the wind blows first gently from the N.E. It veers to the N.W. when the barometer has fallen to 29·8 inches. From the N.W. a gale blows with greater or less fury according to the steepness of the pressure gradient in

the cyclonic area. The wind continues to blow from the N.W. until the cyclone centre has passed over the locality, or if the cyclone is to the N. or S., until the cyclone centre has passed over the line drawn from the locality at right angles to its course. As the centre of the cyclone passes a momentary lull occurs. The wind dies away, but the temperature, which is always high as a cyclone

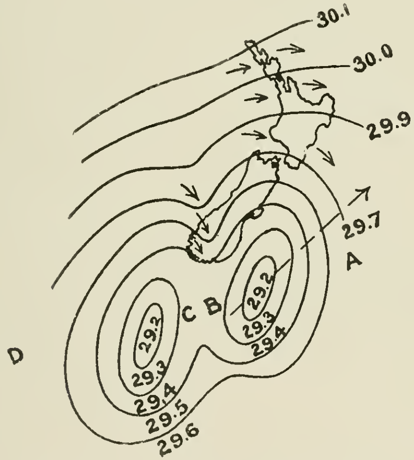
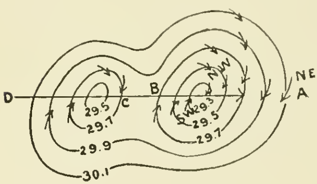


Diagram of Cyclone with a double centre

approaches, does not fall appreciably. Suddenly a blast is felt from the S.W., the barometer rises, the temperature falls, the wind increases to a gale, rain falls. On the west coast thunder and lightning may mark the change, and in the southern parts of the dominion snow and hail and showers of fierce energy and biting coldness may be experienced. After a period of varying duration, according to the size of

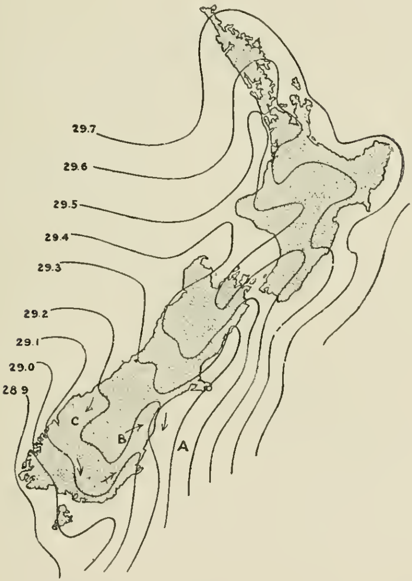
the cyclone, its direction and its velocity, the sky clears, and the barometer reaches a height of 30.2 inches. This description applies only to cyclones that follow the usual course in the New Zealand region from S.S.W. to N.N.E. The extreme simplicity of the weather changes, associated with the progress of such depressions, is much complicated by other subsidiary effects. It often happens that a depression or cyclone has a double centre, the two parts separated by a ridge of comparatively high pressure. The accompanying diagram shows the nature of such a depression. The curved lines are lines of equal pressure, or isobars, and it is clear that the large area of low pressure does not decrease uniformly towards a single centre, but has two centres developed, and to each of these there is an appropriate series of winds blowing inwards. If such a system passes over New Zealand, the



usual succession of winds is first experienced from N.E. to N.W. to S.W., as the parts of the area from A. to B. successively pass onward. As the portion from B. to C. passes on, the wind suddenly backs from S.W. to N.E., although the barometer rose no higher than 29.4. After the backing the ordinary change of wind is repeated, and when the depression has passed so far on that D. has reached the locality, the barometer will have recovered and will stand at 30.2. This type of depression usually produces the most violent gales

and the coldest weather that is experienced in New Zealand.

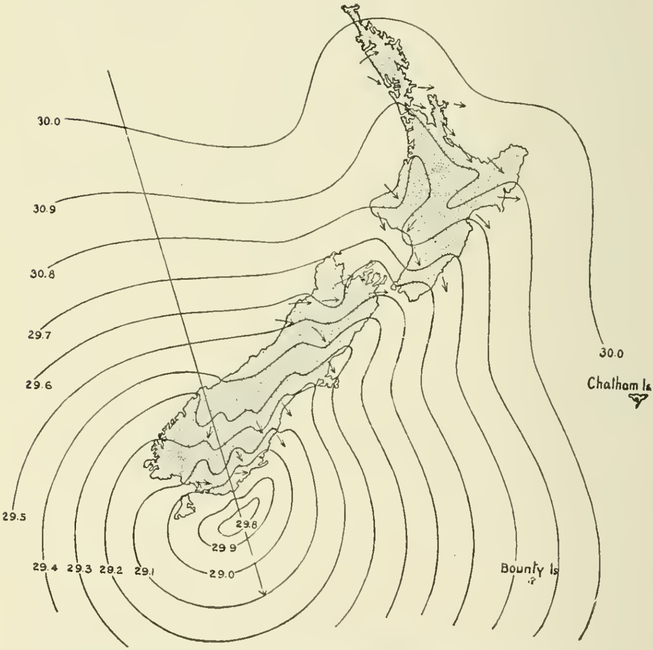
The complications of these low pressure areas are, however, often much greater than this, for the mountains of New Zealand have great local



Map showing tongue-shaped isobars, July 8th, 1879. Captain Edwin, *Transactions, N.Z. Institute*, 1879.

effect upon the distribution of pressure, and the isobars, instead of possessing simple curves as in the figure above are usually tongues of high pressure projecting into areas of lower pressure and *vice versâ.* The passage of these loops or tongues produces the same effect as

the movement of a minor cyclone over any locality. Thus it happens that sometimes during the progress of a cyclone, the wind may back three or four times before the barometer again reaches the height that it registered before the approach of the cyclonic system.



Map showing wind directions after passage of a cyclone from N.N.W. to S.S.E., Feb. 3rd, 1894. From Captain Edwin's weather map.

This ordinary succession of cyclones from W.S.W. to E.N.E. gives the dominant character to the weather of New Zealand. The depressions generally pass to the south of the dominion; consequently their effect is most marked in the southern provinces, and in

Auckland the southerly buster that marks the passage of the centre of the depression is almost unknown. In summer the centres generally pass slightly to the south of Stewart Island. In winter they usually cross the land near a line from Milford Sound to Dunedin.

From time to time cyclones pass over New Zealand from N.N.W. to S.S.E. When such a depression passes to the west of any area the wind will not change to S.W., but stays in the N.W. until the rise of the barometer indicates that the depression has passed on. These depressions often have a steep gradient and very low pressure at the centre. They are usually associated with a heavy rainfall on the eastern coasts. They often have the peculiarity of double centres and looped isobars. In size, any of the cyclones may be as much as 1,000 miles in diameter, and they may move 500 or 600 miles in 24 hours. These depressions largely determine the weather in the northern parts of the dominion where the rain usually comes from the north-east.

Anticyclones, or areas of high pressure, have but little part in determining the nature of New Zealand weather. In many countries anticyclones of great stability develop in the summer, and dominate the nature of the weather for months at a stretch. In winter in New Zealand such areas are rather of the nature of ridges separating two succeeding cyclonic areas, and they are therefore ephemeral in their nature, and cause only transitory weather types. In summer the centres of the anticyclones often pass over the Bay of Islands. While these anticyclonic

areas are present, the weather is fine, light breezes blow, and unclouded skies are frequent.

The alternation of **land** and **sea breezes** that is so marked on tropical coasts is hardly known, except during anticyclonic weather in the northern parts of the land, and in sheltered localities such as Nelson and Kawhia. These breezes are caused by the rapidity with which the land and the air in contact with it become heated during the day and cooled during the night, when compared with the sea. The heated air rises during the day, and a cool inrush of air from the sea—the sea-breeze—takes its place. During the night the sea remains warm, and the air rises from its surface, so the colder air from the land blows as a land-breeze, and takes its place.

A peculiar feature of the New Zealand climate is the frequent occurrence of hot **north-west winds** in the east coast districts. The shade temperature may in summer rise as high as 95° F.—a higher temperature than is ever recorded in the extreme north.

This high temperature is partly due to the fact that these winds blow in advance of a cyclone centre, and the air temperature is always fairly high in such a position. Still the temperature is so much higher than the mere position with reference to the cyclone demands, that some more special explanation is required. It is embodied in these considerations. The westerly winds, when they reach the New Zealand coasts, are fully charged with moisture. They are almost depleted of this as they cross the Southern Alps. The water vapour of steam is condensed to water or even to snow, and its latent heat is acquired

by the air. The effect is not noticed on the mountains except that the snow line is rather high, but, when the air tumbles down to the plains on the eastern side, its temperature is higher than when it left the sea level, for it has acquired the amount of heat that the moisture previously possessed in a latent condition and has on condensation surrendered to the air.

Chapter XIII.—FLORA AND FAUNA OF NEW ZEALAND.

Islands that have remained free from all land connections since their original formation are peopled by plants and animals that have some special means of passing over the watery wastes separating the island from the land of which they are the original inhabitants. Such islands have a population of plants and animals that represent a portion of the population of the land nearest them, or from which oceanic or atmospheric currents flow towards them. In the case of the more remote islands it is only at very rare intervals that a new animal or plant reaches their shores, and even if their formation can be referred to a very ancient epoch, the number of different kinds of animals and plants found on them remains small. The same remarks apply, though with less emphasis, to the marine fauna and flora round the islands' coasts. Islands that have thus remained isolated throughout their existence are called **oceanic islands.**

In most cases land areas that are now islands have during one or more periods in the past been connected with other land areas, and have formed a part of continents. These are **continental islands.** Their fauna and flora naturally show a close relation to that of the continental areas of which they have formed an integral portion. The longer such an island has been separated from its "parent" land area, the more marked are its peculiarities in the varieties and species and even genera of plants and animals by which it is peopled.

New Zealand is a continental island that has been isolated from neighbouring continents for an enormous lapse of time. In consequence of this its flora and fauna are widely different from those of any other land in existence. The complete geographical isolation it possesses at the present time is not the result of recent disturbances of the earth's crust, but appears to be almost the normal condition of this part of the Southern Hemisphere.

It is a curious fact that the two continental areas, with which a consideration of the New Zealand fauna and flora shows that a land connection has existed most recently, are now no longer in existence as continents. Thus the isolation of New Zealand has involved the submergence of those continental lands from which its fauna and flora are derived.

Whilst in the land population of New Zealand, Australian, African, North American, and other elements can be traced, none of these is of so much importance as the **Malayan** and the **Antarctic.**

The connection with the former **Malayan** and

Melanesian continent probably existed at the end of the Cretaceous or beginning of the Eocene period, that is, at a time of immense antiquity, if an attempt is made to estimate it in years, though, when considered in relation to geological time, or to time during which life has existed on the earth, the period is comparatively short.

The animals that have a distribution showing that they reached New Zealand from this ancient continent are for the most part land animals. Almost all the **land birds** show Malayan affinities; the **lizards**, many of the **land molluscs**, numerous **insects** show that this land connection had most important effects on the land population of New Zealand.

Though the Malayan Continent as a whole no longer exists, the numerous islands to the north and north-west of New Zealand are some of its remnants, and it is from a study of their fauna that the truth of the foregoing statements has been proved.

The old **Antarctic** continent, too, is now no longer in existence in a complete state. A remnant of it of large size forms the ice-bound land extending round the South Pole, though its projecting capes nowhere reach beyond the limits of eternal snow and ice. It previously extended further north, and at the same time New Zealand and Australia stretching southwards received from it many of its plants and animals, which soon established themselves firmly on the more northern lands.

The most important immigrants that reached New Zealand were fish, both fresh water and marine. Many molluscs, too, are clearly of Antarctic derivation. The majority of New Zealand earthworms

prove that at one time an actual land connection existed between New Zealand and Antarctica.

The precise time at which this connection between the two lands existed is still a matter not definitely settled. A close comparison of the fish and earthworms of the two districts shows that the differences are so great that they can be accounted for only on the supposition that the land connection occurred at

Tuatara.

the close of the Mesozoic age. On the other hand, Captain Hutton, basing his opinion on the time of appearance of marine mollusca as fossils in the geological strata of New Zealand and on the close resemblance of the Antarctic plants in the New Zealand flora with those of other Antarctic lands, concludes that New Zealand was separated only by a shallow and narrow sea from Antarctica in the Oligocene period. But there are many reasons for believing that the New Zealand extension took place

far more recently. If the suggestion that has been made be afterwards proved, that the New Zealand Moas are more closely related to the Rheas of South America than to the Emu and the Cassowary, it would seem that an actual land connection, and not merely a shallow water one, existed at that time, which was probably the Pleistocene Period.

It is at any rate certain that New Zealand was separated from both of these old continents before land mammals spread to them from other lands. Thus the peculiar fact that no land mammals of an indigenous nature existed in New Zealand is explained.

The only **mammals** found on the islands by the old explorers were a dog, a rat, and a bat. There is no doubt that the two former were introduced into the country by the Maoris—Polynesian voyagers, who came from the north-west. The bat in all probability was blown over to New Zealand from the Australian region.

The New Zealand **reptiles** are also comparatively few and small. There are no snakes, crocodiles, or tortoises. Lizards are not numerous, but one kind, the Tuatara, a bluish grey fringed lizard, eighteen inches long, is of great biological interest. It is one of the most ancient reptile types, whose relatives became extinct in Europe by the middle Mesozoic age. Though formerly existing on the mainland of New Zealand, it is now restricted to outlying islands.

The **birds** are of extreme interest, for the number of flightless birds is very great. The advent of the Maori race to New Zealand was the cause of the extinction of many kinds of flightless birds. The

gigantic Moas, which of several species and in abundant numbers, had roamed over the open lands of both islands, were completely exterminated, being utilised as food. The Notornis, or Takahe, has now almost become extinct, though a specimen is still

Great Spotted Kiwi

very occasionally captured in the wild land between the West Coast Fiords and the southern lakes.

Other flightless birds still exist, though in numbers constantly decreasing. The Weka, or Wood Hen, is a rail, whose wings are now quite incapable of raising it in flight. Most peculiar of all is the Kiwi, related in some degree to the Moas. Its wings are extremely reduced in size, and the bird, which is nocturnal in habit, is now found only in the most densely wooded

districts. The owl parrot, Kakapo, see p. 2 is now found only in the mountainous districts of the south-west of the island. Its wings are incapable of enabling it to fly for any but very short distances. Like the Kiwi, it is nocturnal in its habits.

The Parrakeet of the Antipodes Islands can fly but

Skeleton of Moa.

slightly, and a Duck of the Auckland Islands is flightless.

The cause of the remarkable loss of specialised organs is to be ascribed to the absence of competition of ground animals and to freedom from the attacks of mammals. The birds were masters of the animal kingdom, hence the larger kinds had no enemies to fear. Those whose food was obtained on the ground

for the most part nested under rocks or in hollow trees, and to them wings were useless appendages, and disuse of them was followed by degeneration.

The rapid extermination of the Moa by the Maori can be explained by the effect that immunity from the attacks of enemies for many centuries had upon the intelligence and instinct of self-preservation. The Moa was probably a stupid and perhaps a slow bird, and was thus an easy quarry for even the most primitive race of man. The active and resourceful Maori, judging by the remains found in old camping-grounds, killed the birds in numbers, and devoured quantities of their eggs. Wanting in prescience and careless of future scarcity, the Maoris made no attempts to stave off the extinction that was the inevitable result of such destruction, and ere long the Moa vanished from the land.

At the beginning of the century the coasts of New Zealand, especially in the southern portion, were visited by large numbers of **seals**. At the present time they are rarely seen on the coasts of the main islands, though the south-west sounds are still the home of some Fur Seals. The outlying islands to the south are still visited by numbers of the Fur Seal, and in the Auckland Islands the Sea Lion is found in large numbers.

European influence is responsible for the enormous reduction in the numbers of the Fur Seal on our coasts, for seal skins were exported in large numbers in the early part of the nineteenth century. It is now almost extinct, and the surviving remnant is protected by legal enactments.

The **Sea Leopard** occasionally visits our coast.

Whales were also abundant in the surrounding ocean waters until after the middle of the century, but the Right Whale and Sperm Whale are now rare, though the Fin-back and the Hump-back are still fairly common.

The Whales also were killed in large numbers by whaling ships of English, Scotch, and American origin. The Right Whale was first hunted; the Bay of Islands was the chief station, and some hundreds of vessels made this port their headquarters. The whales were attacked at sea, and also when they

Sperm Whale.

came into the shallow bays for breeding. The number killed was so great that by 1840 the industry had already begun to decline. At the present day the Right Whale is a rarity. The Sperm Whale had its home chiefly off Stewart Island. This "fishery" did not commence until the numbers of the Right Whale had been greatly thinned; then the operations were carried on with such vigour, that for many years the Sperm Whale has been a rarity in New Zealand waters.

Black Fish, Porpoises, and Dolphins are abundant in most parts of the coastal waters.

There is an abundance of **fish**, and many of the kinds are edible. They formed one of the main

sources of food supply of the Maori population, and at the present day the fishing industry is of some importance.

Penguins were formerly common on the rocky coasts of New Zealand. They are still found in the more out of the way localities, and are excessively numerous on the shores of the outlying southern islands.

Insects are fairly numerous, though butterflies are few in number, and almost wanting in those gorgeous colours that make them such an attractive portion of the fauna in many countries.

A noticeable feature of the New Zealand fauna is its harmlessness. All the reptiles are innocuous, and with the exception of a small poisonous spider (the Katipo) and biting insects such as the Mosquito and Sandfly, there are no species that can do man any injury.

Introduced Animals.

Various animals have been **introduced** into the dominion, and those that hail from similar temperate climates have increased and thriven, whether domesticated or allowed to run wild.

The various farm animals such as sheep, cattle, and horses, now constitute the chief sources of wealth of the community. The red deer have flourished in some of the mountain districts, especially in the Tararua Mountains in the North Island, and in the Lake Hawea district in the South. Fallow Deer are abundant in many districts. Attempts are now being made to acclimatise many kinds of deer in the mountain areas. Rabbits have particularly flourished,

and now constitute the greatest scourges in many of the pastoral regions of the South Island. In the sparsely settled districts it has been found almost impossible to reduce their numbers.

European birds have, in the more settled districts, almost entirely ousted the original kinds, and have themselves in some places become a serious pest. It appears that the vitality of any species, when introduced into a new country where life conditions are widely different from those in the country of their origin, may be completely changed. The remarkably rapid increase of some species must be largely ascribed to the absence of natural enemies in the new home. The introduction of a new kind of animal temporarily disturbs the balance of nature. This view of the matter has prompted the introduction of stoats and weasels and other natural enemies of the rabbit. Experience so far has shown that these vermin have a greater effect in reducing the numbers of the native birds, whose habits render them specially prone to attack, than in checking the ravages of the rabbits.

The Flora.

Peculiarity of New Zealand flora.—Sir Joseph Hooker in the introduction to his *Flora of New Zealand* has remarked on the great peculiarity that it displays. He states that no botanist familiar with the plants of any other country would find himself at home in the New Zealand forest. The differences between the plants of New Zealand and those of Australia he considers specially striking when the proximity of the two lands is considered.

Three-quarters of the indigenous plants are absolutely confined to New Zealand in their distribution, though the genera to which they belong are nearly all the same as Australian genera. One-third of the plants of the South Island do not occur in the North, and one-fifth of the Northern plants have not been found in the South Island. Two plants particularly well-known in New Zealand—the native Flax, or Phormium, and the Karaka—are without close relatives elsewhere, except that Norfolk Island has a similar flax.

Some New Zealand genera, such as Veronica, are represented by numerous species, while in Australia there are very few. On the other hand, the reverse is found in the genus Persoonia and several others. The complete absence of the Gum trees (Eucalyptus) and Wattles (Acacia) of Australia throughout New Zealand is a very marked feature.

The most generally distributed of forest trees in New Zealand are the Pines.* With the exception of the Kauri, which grows only to the north of 39° N. latitude, the majority of them occur in fair abundance in suitable localities throughout the islands. The species are all peculiar to New Zealand, but the genera to which they belong are Malayan in their distribution. It appears most reasonable to account for the differences and resemblances between New Zealand and Australian plants by supposing that both countries had additions made to their original flora by immigration along a land connection from the Malay continent, though this connection was not

* The Pine trees are conifers but do not belong to the European genus Pinus.

sufficiently lasting to allow of a complete mingling of the flora.

An important element in the New Zealand flora is that of **South American and Antarctic** origin. The identity between the New Zealand Kowhai and a plant in South America combined with its absence elsewhere, is most striking. The Tutu and the Piripiri (Aeœna) have also a complete Antarctic distribution. The relations between the New Zealand flora and that of the Antarctic Islands suggest that a land connection existed within late Cainozoic times, thus confirming the indications afforded by a study of the fauna.

From a **scenic** point of view there is little that is strikingly characteristic of the New Zealand vegetation. The Tree Ferns and the so-called Cabbage Trees—the latter in reality large liliaceous plants—are very common almost everywhere. In the north, the Kauri pine at once attracts attention, but in the south, the forest vegetation is mixed without any one tree predominating, except on the eastern slopes of the mountain ranges, where the sombre dark green colour of the beech forests is often unbroken.

Flowering trees and plants are comparatively few. The various kinds of Rata, especially the Christmas tree, or pohutukawa, that covers the sea cliffs of the north, and the Forest Rata of the south-west, have dark crimson flowers that add colour to and Zealand and Australian plants by supposing that both whitens the hillsides in spring. Many of the mountain plants bear large flowers, especially the large Buttercups and Mountain Daisies, but they are

nearly all white, and though individually fine and striking, they do little to vary the colours of the landscape.

When the early settlers reached New Zealand, the greater portion of the land was covered by a thick growth of **primæval bush**. This was denser and more continuous on the western coasts than on the eastern. In districts where the rainfall was light or the soil poor, the land was "open," that is, covered by a growth of grass, fern (Pteris aquilina), light shrubs, or scrub. Thus the Canterbury and Southland plains and the interior of the Otago Province were grass lands. The Taupo plains were covered then, as now, by a growth of Manuka, low Bracken Fern, and Tussock Grass. On the clay soils to the north of Auckland and elsewhere there was a similar growth. In many of these localities old charred logs and stumps and kauri gum show that at some prehistoric period much of this open land had been forest.

The forest or bush of the lowlands is mixed. At the higher altitudes Beech (birch) trees become more prominent, and at 3,000 feet, generally displace all other kinds. Above 3,500 or 4,000 feet, the zone of scrub is composed chiefly of Veronica and Olearia shrubs. From 4,500 to 6,000 feet, Snow Grass and small Tussocks prevail, and alpine plants extend up to 7,000 feet in sheltered spots on the mountain flanks.

The indigenous vegetable products of New Zealand viewed from an **economic** standpoint are, with the exception of forest trees and Phormium or Native Flax, strikingly poor. The Maoris cultivated the Kumara (sweet potato or yam) and the Taro, but

A Cabbage Tree.

these, like the dog and the rat, were brought by them when they immigrated into New Zealand. Their other staple, the Fern Root, has never commended itself to Europeans. Captain Cook highly praised the virtues of a native Celery as a preventive against scurvy, but it has not been cultivated. A kind of Gourd was used by the natives, but it is inferior to European varieties.

Though there are many **native grasses**, they are for the most part ill adapted for pasture. The stronger kinds of Poa and Danthonia, grow into hard rank tussocks that are not much relished by cattle or sheep. The smaller and weaker kinds are largely destroyed by the grass fires that are found necessary on the native pastures to keep down the growth of tussocks. The native grasses, however, often flourish on stony soils and exposed mountain sides, where European grasses will not grow. Even now the greater part of New Zealand grass land is still "native pasture."

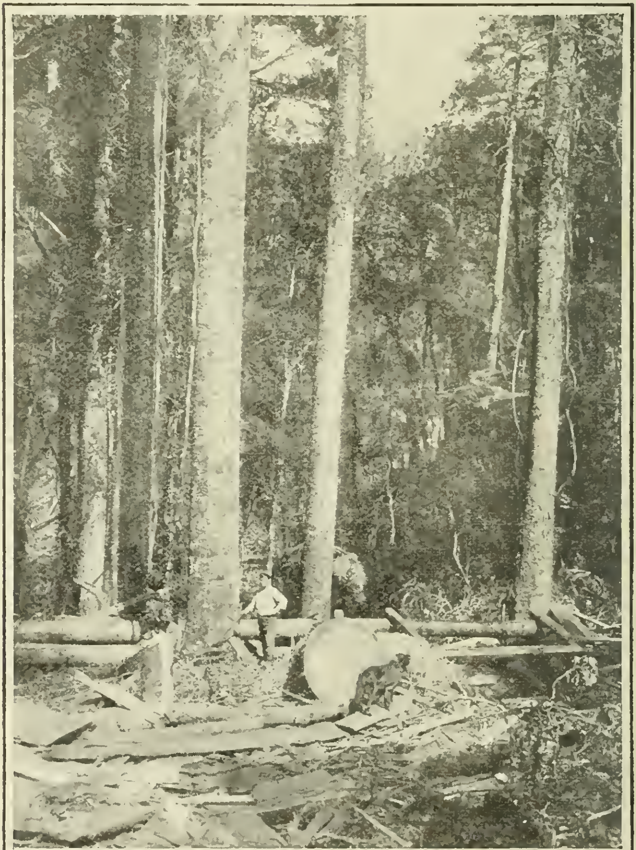
The forests of New Zealand still furnish large and valuable supplies of **timber**. At the beginning of the century, the Auckland Province was visited, especially by admiralty vessels, for supplies of Kauri spars, which could then be easily obtained in lengths of great thickness and very straight. Afterwards sawmills were erected, and at the present time fears are entertained that the supply will soon be exhausted. This tree provides the best timber for general purposes that can be obtained in New Zealand, but at the present rate of destruction the forests will be destroyed in 15 years.

Several other pines afford good timber suitable

Mountain Buttercup.

Celmisia.

for various purposes. The Totara, in particular, produces timber that is specially resistant to those



Kauri Trees.

fungi that cause rotting, and to the attacks of the marine worm (Teredo). The Rimu, or Red Pine, is used in the south for house building. The White

Pine is also milled to a considerable extent. Within recent years its wood has proved particularly valuable for the manufacture of butter boxes. The so-called Birches, in reality Beeches, clothe a large portion of the eastern slopes of the mountain ranges in the South Island. Though some kinds are large well-grown trees, the timber that is sawn from them is not of much value.

Like the native animals, the New Zealand plants have suffered greatly from the changed conditions that have resulted from colonisation. The more vigorous growth of **introduced plants** has often driven the native kinds far afield. The burning and destruction of bush and the periodical burning of native pasture have been disastrous to the indigenous vegetation. The destruction wrought by the cattle and sheep of settlers has locally exterminated some of the weaker species. At the present time, there are many districts in New Zealand where no native plants are to be found. But few of the native plants have been cultivated. Few have showy flowers; most species grow slowly; the majority require the special conditions of their native habitat; very few have any economic importance. Thus it is that the dweller in our towns or agricultural districts seldom sees the foliage or flower of native New Zealand plants.

PART III.—POLITICAL AND COMMERCIAL.

CHAPTER I.—LATER COLONISATION AND GROWTH OF SETTLEMENT.

With the exception of the Canterbury Province, New Zealand did not advance very rapidly in the early days of settlement. Twenty years after the colony had been proclaimed the population had not quite reached 80,000, so that, notwithstanding the arrival of the large bodies of "pilgrims" at Nelson. Taranaki, Otago, and especially Canterbury, the average rate of increase of population was only 4,000 per annum for those twenty years. This comparatively slow advance was due to the fact that the extension of settlement was difficult because of the hilly nature of the country, which made road formation an arduous matter, so that out-settlers were almost unable to carry their produce to any centre whence it could be exported. The difficulty of buying native land in the North Island, and the expense of clearing and burning the dense forest on its surface, prohibited rapid expansion of areas of settlement. In Canterbury the level surface of the eastern plains, the rich soil that covered a large portion of that surface, and the ease with which roads could be made, allowed of comparatively rapid progress; and at the end of this period Canterbury had taken that foremost place among the provinces

that she was destined to hold almost until the present day. Even in 1901, the exports from the two Canterbury ports, Lyttelton and Timaru, exceeded those from other provinces, though in 1902 the exports from ports of the Wellington Province were of a slightly higher value; but in 1903 Canterbury again led the way, though in recent years Auckland and Wellington have taken a decided lead.

This period of slow development of settlement and gradual advance of the pastoral and agricultural industries was changed at the close of 1860. During 1860—1870 two other matters, quite distinct from any details of geographical configuration, determined the rate and progress of settlement. A new source of wealth was developed and gold poured into the pockets of southern settlers and diggers, who came to the country in swarms. In parts of the North Island on the other hand settlers were fighting for their lives and homes against a brave and warlike foe. **Gold** was first discovered in 1852 at Coromandel, and in 1857 a payable goldfield was opened at Collingwood; but in 1861 the discovery of the rich alluvial fields in Otago attracted crowds of adventurous diggers from Australia, California, and elsewhere.

This gold, torn by the resistless and unceasing action of running water from its home in the schist rocks of Otago, was too heavy to be carried to the sea by the rivers. There it lay in the riverbeds, while through untold ages the rocks in which it had been embedded were gradually worn away, ground up, and their light stony matter carried to the sea. Thus the gold that was spread over thousands of miles of

country in rock masses thousands of feet thick had been accumulated, and was waiting for the enterprising hands of miners to separate it from the residue of sand and gravel that had not yet been washed away. The diggers penetrated into every gully and stream bed in Otago in search of new deposits. As each deposit became exhausted, a few of the diggers remained and eked out a living with the aid of pastoral occupations, and some became permanent settlers. The opening up of new lands induced many of the old settlers to go far afield, and thus the frenzied rush of the diggers resulted in the rapid and extended permanent occupation of the land.

The diggers required much food for their large camps; and the steps taken by old Mackenzie to supply this want form one of the most romantic chapters in the geographical exploration of New Zealand. Employed on one of the out stations of Canterbury, he discovered whilst searching for sheep, a vast level plain behind the high range of hills fronting the Canterbury Plains. Leaving his employment he stole sheep from the out stations and drove them over the hills into the grassy plain beyond. From time to time as his flock grew large, he drove it right over the back country to the Otago goldfields. When at last the thefts were traced to their author, the huge plain into which the tracking party suddenly burst was christened the Mackenzie Plains.

Even more important from a geographical point of view was the discovery of gold in Westland. On

the beaches and in the older gravel formations there was much gold. The rush that set in after its discovery peopled what had previously been a waste wilderness. The prospect of fresh discoveries stimulated geographical explorations. The stormy wet climate has prevented an extensive pastoral or agricultural population from following on the heels of the miners, and the mining industry is still the chief one in this isolated portion of the land. Had it not been for the mineral discoveries in this region, it is possible that Westland would still be as little known as the land bordering the West Coast Fiords, where the coast line and its details have been known since the beginning of the century, though at a short distance from the sea margin the land is not yet explored.

The other important event of the sixties—the Maori war—retarded settlement over the greater part of the North Island. Some of the outlying settlers were murdered, and for a time it seemed doubtful whther any Europeans living remote from centres of population would ever be safe from the attacks of natives frenzied by religious fanaticism. The effect in the end was, however, partly in the direction of promotion of settlement. The suppression of the disturbance involved the movement of troops over much land previously untrodden by Europeans. A heavy indemnity in the shape of land confiscation was imposed. Thus, when security reigned once again, more of the land was known, and more was open to settlement than before.

During the seventies many public works were

undertaken by the government. Immigration was subsidised and settlement was pushed forward more rapidly. It was too often found that the immigrants were not sufficiently aware of the difficulties that they would have to encounter. In many cases they were given land grants in wet bush districts with few roads to their land. For these reasons the **state-aided immigration** did not produce immediately the beneficial effect expected. As in time the immigrants became acclimatised and their land was cleared, there is no doubt that they added materially to the progress of the country.

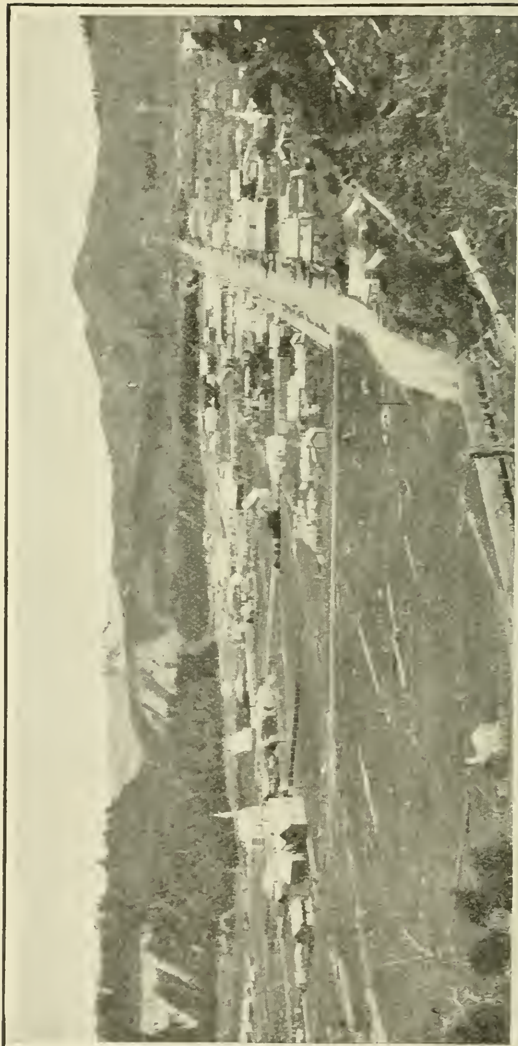
For the last twenty-five years advance has on the whole been steady. The construction of railways, the formation of roads, and the building of bridges have enabled settlement to push forward gradually in all directions.

In the peninsula to the north of Auckland the land has in the past been more extensively covered with **Kauri forests** than at present. From these ancient trees resin exuded, and, when the trees died, the wood decayed and the resin became covered with soil. The forests have now disappeared, but the resin remains buried in the clay and constitutes the well-known **Kauri gum.** Thousands of diggers support themselves by unearthing this gum, which is a valuable commodity. The population is, however, an unsettled one. As a locality becomes exhausted of gum, the diggers move on. They seldom take up land and establish a permanent home, partly because the soil of the gumfields is poor, and partly because the more industrious and energetic people are seldom attracted by the occupation of gum-digging. Of late

years pastoral settlement has been stimulated by the establishment of the frozen meat industry. Better returns can thus be obtained from the land, and more complete settlement has resulted in many of the more distant pastoral districts.

On the other hand, pastoral interests have in the southern districts of New Zealand received a severe check from the plague of rabbits with which the country has been overrun. This is particularly the case in the grassy uplands of Otago, and to a smaller extent in Canterbury and Marlborough. On the poorer land where the country has to be farmed in large runs, it has been found impossible to control the destruction to pasture caused by the rabbits. In some cases large areas of country, otherwise well suited to pastoral pursuits, in Western Otago have been surrendered, and thus the fringe of settlement has been pushed back. For some time an attempt has been made to export the rabbits as frozen meat, as well as to sell the skins for furs. This practice is condemned by the stock inspectors, as tending to stimulate the farming of rabbits and thereby to increase their numbers. In many districts of late years the rabbit pest has decreased.

The **dairying** industry has lately shown a very remarkable development in bush districts, where the rainfall is high and the growth of grass rapid. Especially is this the case in the Taranaki and Wellington provinces, where much land is occupied for dairying that would be far less suitable for ordinary pastoral purposes. The expense of bringing bush land into cultivation is quickly recouped by the produce from a dairy farm.



Mangaweka: a new bush settlement on the North Island Main Trunk Railway line.

The progress of settlement has not yet reached its final stage, for much good **bush land** yet remains to be cleared and converted into farms. The area available for this purpose is especially large in the North Island. Advance in this direction must be slow, for even when the bush has been felled, the formation of roads over the hilly clay lands is expensive, and proceeds but slowly. In the meantime, the government has passed legislation enabling the crown to purchase large estates that do not at present support a dense population. These are cut up into small farms, which provide homes for large numbers of farmers. This enables the occupied land to support more people, but it does not extend the area of settlement.

When New Zealand was first colonized, the surface of the land was of course covered everywhere with indigenous vegetation. Those portions of the colony favoured with a heavy rainfall were generally clothed with a dense forest. In the volcanic region of the North Island, where the loose pumice soil retained but little of the rain that fell, only fern and manuka scrub were found. In the drier and more exposed areas tussock grass, or occasionally fern, was growing.

The bush or forest land has required the expenditure of much capital and labour to bring it under cultivation. The practice is to fell the bush, and as far as possible burn it off the land in the succeeding summer. Grass is at once sown, and cattle are turned on to the land when the growth of grass is sufficiently strong. The charred trunks of the prostrate trees, the gaunt skeletons of the larger trees which are

usually left standing, produce a spectacle of desolation, which is at first the most striking impression conveyed by newly cleared bush settlements. As time goes on, the standing skeletons fall, the prostrate trunks decay away, and the picture of desolation is replaced by the cheering aspect of green-grassed fields, on whose surface an occasional stump is the only evidence of the forest growth that covered the land before it was changed and adapted for human occupation. Twenty years at the least are necessary in order to allow of the complete disappearance of the forest, and even then the tree stumps prevent the ploughman from preparing the land for crops. The expense of clearing the land and the small returns obtained from it in the early years of occupation render the process of forcing the line of bush backwards a slow one. Much has been done, and much is being done. The "forty-mile bush," traversed by the railway line at the head of the Wairarapa country is now replaced by forty miles of farms. The belt of bush east of Mount Egmont traversed by General Chute's forces during the Maori war with great difficulty, and in the face of almost insuperable obstacles, is now a region of rich dairy farms adding no small quota to the total of New Zealand exports. In nearly all instances, bush land, when cleared, is well suited for pasture and dairying, and in time to come will grow crops of cereals.

The **volcanic land** covered with fern and scrub, the so-called bracken and tea tree, has hardly been touched. The volcanic pumice and other rocks contain all the substances required to promote plant

growth of all kinds. Its mechanical condition is the cause of its barrenness. If some method industrially feasible can be found to consolidate the surface of these huge plains of loose pumice, the land may yet be changed into fertile farms.

When the soil of **fern land** is good, the fern is burnt off the land, and grass is sown. As soon as the young fern fronds sprout up, the land is, if possible, heavily stocked with sheep. The growth of the fern is then checked, and the grass gets the mastery. Much land in Hawke's Bay, originally covered by a waste of fern, has now been converted into rich agricultural land.

The original **grass lands** were suited for immediate ploughing and cultivation, or, in the more hilly regions, were waiting for flocks and herds. The native grasses are chiefly so-called tussocks. The plants grow in large dense tufts, and bear a fair quantity of hard, stringy narrow leaves. These are not much liked by stock, but the smaller and weaker grasses that grow between the tussocks are usually more nourishing. The tussock land is often interspersed with areas of shrubs of a hard and thorny nature. It is found that, after burning the tussock annually, a growth of young nutritious foliage is produced on the tussocks; at the same time the scrub is slowly destroyed, and the land is slightly improved from a pastoral standpoint. It is generally found necessary to plough the tussock land, and sow European grasses. if it is desired to convert it into superior pasture. This is done in all the richer districts; but the poor lands, especially on the

mountain sides are more satisfactory if left as native pasture than if sown down with European grasses.

Swamp land is not abundant in New Zealand, but some original swamp has now been drained and converted into rich agricultural land. This has been done with success in parts of the Canterbury Plains, and at the present time the great Piako swamp at the head of the Firth of Thames is being drained and occupied.

There are now 4,750,000 acres of grass land that have been ploughed before being sown. 8,870,000 acres have been sown without ploughing—often originally bush land—and 22,525,000 acres are covered with native pasture. This gives a total of pastoral land of 36,145,000 acres. When this quantity is compared with the area officially considered fit for agriculture and pasture, it is evident that there is still much room for the settlement and agricultural development of New Zealand.

In the North Island, there are 13,000,000 acres capable of being made fit for agriculture, and in the South Island 15,000,000 acres. In the North Island, 14,200,000 acres are too steep for agriculture, but suitable for pasture. In the South Island, the amount is 13,000,000 acres.

In the North Island, only 300,000 acres are returned as barren mountain tops above the possible limit of pasture. In the South Island, there are 9,000,000 acres of such land.

Thus, there are altogether 55,200,000 acres that can be utilised for farming purposes, and at present only 36,145,000 acres have been utilised in this way.

Chapter II.—PRINCIPAL INDUSTRIES OF NEW ZEALAND.

The climate and soil of New Zealand allow of the successful growth of all those animals and plants that have constituted the source of wealth of most European nations. The most important of our industries are founded on the growth of these plants or on the products of the animals. There are in addition extensive forests of fine timber trees. The industry that adapts the wood for sale in the markets of the world has throughout the history of the dominion been an important one. The deposits of valuable and useful minerals have enabled the mining industry to be followed by large numbers. Lastly, the native "flax," properly a lily (Phormium) supplies a useful fibre, and the interesting fields of Kauri Gum are of a more special and peculiar nature.

Wool has since the very early days of colonization been the staple article of export. Except for the ten years from 1861-1871, its value has been greater every year than that of the gold produced. The quantity of wool has shown a gradual increase—though with slight yearly decreases from time to time—from 1853, when the amount was 1,000,000 pounds to the year 1907, when it had reached 171,500,000 pounds. The small decreases that have been recorded must be ascribed to the effect of unfavourable seasons. For instance, the winter of 1895 was an especially severe one in the South Island, and

thousands of sheep perished in the snow. The wool production for that year shows a sympathetic reduction of 28,000,000 pounds, and three years more were required to bring the quantity up to the amount recorded in 1894. Although statistics show a diminution in the total production for the whole colony, the effects are in reality local. It often happens that a severe winter in Canterbury that has disastrous effects on the stock is not experienced with any approach to the same intensity in the neighbouring province of Otago, and *vice versâ*; while in the North Island the winter storms are never severe enough to cause a wholesale destruction of sheep, though a tempestuous spring is often destructive to the lambs, and reduces the natural increase for the year. The value of the wool produced shows greater and more important variations than the amount recorded. This is, of course, due to variations in the price given in the London market, which, unfortunately, fluctuates considerably. Thus, in 1901, the wool produced was 6,000,000 pounds more than in 1900, but the price obtained totalled £1,000,000 less. On the whole, there has been a satisfactory continuous increase in total value, though the largest return for wool sales in a year was £7,657,000 in 1907, though the quantity was only nine million pounds more than in 1908, when its value was only £5,332,000, and 18,000,000 pounds less than in 1909 when its value was £1,350,000 less than in 1907. The production of wool in 1909 was much greater than in any preceding year. In 1907 there was the nearest approach to this quantity. The wool export has been the principal one in the past history of the dominion,

and there is every reason to anticipate its future permanency in this position. Though we are further away from the important London market than are Australia and the Argentine, advantages of climate or of government almost compensate for the disadvantages of our more remote situation.

Frozen Meat.

Though the chief export resulting from the pastoral industry has always been wool, yet there are others that have been of considerable importance throughout the history of the dominion. Amongst these, **hides and pelts, tallow,** and **tinned meat** are the most notable. Within recent years the **frozen meat** export has eclipsed all of these. Commencing in 1882, when the value was only £19,000, and the experimental stage had not been passed, there has been a very rapid advance in the quantity and value of frozen meat exported. In very few instances have the returns for any one year been less than those for the preceding. Such fluctuations have been small, and have always been succeeded by an increased advance in later years. So rapid has been the increase that in 1902 the value had reached £2,700,000, and in 1909 £3,600,000, an amount that exceeds the value of every other export for the year, with the single exception of wool. The increase in this export had been relatively small between 1902 and 1906, though 1909 showed a great advance, and there has been in these last three years a still greater advance in the number of sheep, which in 1909 was 23,480,000. The advance in 1907 and 1908 has been associated with a stationary condition or decline in the dairy export,

though a satisfactory recovery was shown in the latter in 1909. It appears that the number of sheep varies to some extent inversely as the number of dairy cattle, though both on the average slowly advance as more land becomes settled. The development of this export of the surplus of our flocks has largely increased the number of workmen who owe their support primarily to the pastoral industry. It has necessitated the building of large freezing establishments in various parts of the dominion, and in these employment is provided for a number of men that materially add to the proportion of workmen directly dependent on the pastoral industry. The development has emphasised the necessity for the construction of railways to the more remote areas of settlement, and has materially added to the returns derived from their management.

The total value of the meat freezing works of the dominion exceeds £1,475,000, and nearly 3,200 hands are employed in them.

The **principal areas** over which the **pastoral industry** is of special importance are:—

In the Auckland Provincial district: the Waikato and Raglan districts; the Poverty Bay districts; the neighbourhood of Auckland.

In the Taranaki Provincial district the purely pastoral industry is to some extent supplanted by the dairying industry.

In the Hawke's Bay Province, the greater part of the land is devoted to the purely pastoral industry.

In the Wellington Province, much of the Wanganui coastal plain is purely pastoral. The Wairarapa

district and the Eastern districts are almost entirely devoted to sheep farming. In this province, too, dairying is making important strides, and some pastoral land is now being devoted to dairying. There are more sheep in this province than in any other.

In the Nelson and Westland Provinces, the pastoral industry is not of very great importance. In Marlborough, there is much pastoral country in the south and east parts of the province. The land is, however, rough, and the soil usually poor, so the wool export forms an item far more important than the frozen meat.

The Canterbury Province for a long time had a greater pastoral industry than any other. On the rich plains the best type of sheep for frozen mutton is extensively grown, so that Canterbury mutton has become a synonym for the superior grade of that export. The lower ranges forming the eastern part of the Southern Alps are well adapted for pasturing sheep, though wool is of greater value than the frozen meat from these districts, for the care and attention necessary to fatten sheep for the meat market cannot be bestowed on them in the rough country.

The Otago Province is also chiefly pastoral. The export of frozen meat is of much less value than that of Canterbury, for there is not such a large expanse of flat rich land as in the Canterbury Province. There is, however, a still larger area of broken mountainous grassy uplands, on which sheep of the hardier breeds thrive, though the number that the land can support is much reduced by the competition of

rabbits, which swarm over the country. From the eastern coast line to the lakes, the sheep farming industry is prominent.

The relative importance of the purely pastoral industry in the different provinces is given in the following table showing the number of sheep in each province in 1909:—

Wellington	5,000,000	Marlborough	1,010,000
Canterbury	4,625,000	Nelson	1,020,000
Otago	4,580,000	Taranaki	710,000
Hawke's Bay	3,380,000	Westland	43,000
Auckland	3,100,000		

Of these, Auckland, Wellington, Marlborough, and Otago showed important increases on the previous returns, while the others showed little change. The total number of sheep was thus 23,480,000. During 1909, the total number of those exported and of those consumed in the country was 7,500,000. It appears that after allowance has been made for losses, which are exceptionally severe in the rough country of the south, the average natural increase does not allow of any great annual advance in the number of sheep in the country, if the number exported is maintained.

The **advantages** that New Zealand possesses as a sheep farming country are due to the climate, which allows of the growth of a good uninterrupted staple of wool, the great natural increase which amounts to 80%, and the large amount of land suitable only for sheep farming, whose value cannot be made too high by the competition of other more lucrative industries.

In 1903, the returns for every province showed a decrease in the number of sheep. The amount was

greatest in the Wellington province, where it reached to 428,000. In this case, the decrease was partly compensated by the great increase in the dairying produce from the dairy cows, which increased by 12,000. The total decrease in the number of sheep in the colony was 1,400,000, and the increase in the number of cattle 133,000. In 1908 the sheep increased by 1,465,000 and the cattle decreased by 40,000. In 1909 the sheep increased by 960,000.

Agriculture.

Up to the present time only a small portion of the land that is suitable for agriculture has been made use of for this purpose. Oats are grown more largely than wheat, and the production of barley, maize, and rye is quite small. The Canterbury Plains are by far the most important of the wheat yielding localities. In 1910 a little more than two-thirds of the yield for the year was grown on them. Nearly the whole of the balance was grown in Otago, where the Taieri Plains, the Oamaru, and the Southland Plains are the wheat growing areas. The yield of wheat per acre is much larger in New Zealand than in the states of the Australian Commonwealth. Within the last twelve years it has never been less than 18 bushels per acre, and in 1903 the average was 38 bushels per acre, but in 1910 only 28 bushels.

The value of the grain exported varies very widely, as it depends upon the weather at harvest time, the amount of land given to cropping, as well as the average price obtained. In 1898 the export was worth £135,000, in 1901 £1,300,000, in 1903 £500,000, in 1909 £823,000.

Mining Industry.

The discovery of mineral wealth inaugurated the rapid advance that New Zealand has undergone since 1863. Before that year the land had been colonised only as a country whose climate and surface were adapted for pastoral, and in a minor degree for agricultural industries. It was the discovery of rich alluvial gold diggings at Gabriel's Gully in **Otago** that completely changed this aspect of affairs. Gold had been discovered previously in **Coromandel**, **Collingwood**, and in Otago itself, but, with the exception of Collingwood, none of these discoveries had resulted in the establishment of a notable mining industry. The sudden inrush of a large number of diggers had an important effect upon the general development of the colony, as has been noted previously. Alluvial deposits of gold are always local and patchy, and such fields seldom have any permanency. It was at first hoped that the source of these rich deposits would be found in quartz reefs of fabulous richness in the mountains from which the rivers flowed. It is now understood that these gold bearing gravels owe their gold contents rather to the enormous lapse of time during which their accumulation has taken place, than to the specially auriferous nature of the rocks that have been worn down into gravels.

The quartz forming small reefs throughout the Otago schists is auriferous, but the amount of gold in it is small. In but few localities are there payable reefs. The gold found in the gravels is the residue of a tremendous thickness of rocks with poorly auriferous quartz reefs, that has been very

gradually removed by the running water to whose action the formation of the mountain ranges themselves is due.

The discovery of these alluvial fields in Otago in 1861 was followed three years later by a similar discovery on the **West Coast**. Here again, the gold is a residue of an enormous amount of rock waste, but in this case is derived more from quartz reefs of low value contained in a small restricted belt of country.

The beach sands on the West Coast were as auriferous as the gravels. They are not yet exhausted, though some economical method is required to separate the gold from the large quantity of magnetite (a heavy black oxide of iron) with which it is mixed.

At the **Thames**, quartz reefs of extraordinary richness were discovered about the same time as the West Coast deposits. In the Caledonia mine in particular the "bonanzas" were of almost fabulous value.

Still later, quartz reefs of moderate richness were discovered and developed at **Reefton**. As a result of the earlier discoveries, the gold export reached its high water mark of 735,367 ozs., value £2,844,517 in 1866. This total was again approached in 1871 after the discovery of rich reefs at the Thames, but from 1880 to 1898 there was a serious decline, and the gold yield was always less than 300,000ozs. Of late years an increase in the yield has been important, and in 1902 the total was nearly 508,000 ozs., value £1,950,000, though in the meantime it had twice fallen

to 187,000 ozs. Since 1902 the production of gold has not varied greatly in amount.

The increase of the last few years is entirely due to two new developments, the one of a mechanical nature that has chiefly affected Otago, the other of a chemical nature that has enormously increased the production of the Thames district.

The former is the use of the **gold dredge**. The dredges are flat bottomed punts provided with machinery, by means of which the gravel forming the bottom of the water on which they float is mechanically lifted, and from it the gold is separated by ordinary washing methods. By this means the gravel river beds are partly deprived of the gold that they have hoarded through untold ages.

The latter development referred to is the application of the **cyanide of potassium** solution for the recovery of gold from the ore in which it occurs. The potassium cyanide dissolves the gold in preference to the other substances present, even when their nature precludes the extraction of the gold by other methods.

The application of this process to the quartz reefs of the Thames district has enabled several mines to yield annually large quantities of gold, though by the use of other methods no payable returns could be obtained. The importance of this fact is at once apparent when it is stated that the Waihi mine was a failure until the cyanide process was used for treating its ore. The returns from the mine have continually increased since then, and in 1902, ten years after the first use of the process, £521,000 value of bullion were obtained. In 1909 £959,000 was the amount.

The **methods of mining gold** now made use of in New Zealand are as follows:—

1. Washing of auriferous sands and gravels. A stream of water washes away the light material and leaves the heavier gold behind. Practised on the West Coast beaches and in the gravels of Otago, West Coast and Collingwood.

2. Hydraulicking or sluicing. A powerful jet of water is directed at the face of a gravel cliff, and the cliff is gradually washed away. As before, the light material is removed and the gold remains. Practised in Otago, West Coast, and at Collingwood.

3. Dredging. Gravel from river beds is raised and washed. Practised chiefly in Otago and West Coast.

4. Quartz Mining. The quartz is excavated by the miner and taken to the surface. There it is crushed in batteries, and the gold is afterwards extracted by chemical means.

For many years no entirely fresh goldfields have been discovered in New Zealand. The great advance in the gold returns noted in recent years has been due to slight extension of previously known auriferous areas, or to the application of new methods of extraction to deposits previously known. It is unlikely that any large new goldfields will be discovered in the future.

In 1908 the gold production of the world was more than 21,000,000 ozs. Of this total Australia contributed 3,050,000 ozs., and New Zealand 470,000 ozs. Of the Australian states, Western Australia and Victoria produced more gold than New Zealand.

The value of the gold produced within the dominion

since its first discovery to March 31st, 1910, is almost £76,000,000.

Incidentally the goldmining industry has largely increased the silver yield. In the Thames goldfields a high percentage of silver occurs with the gold in the quartz reefs. The cyanide process of separating the gold from the ore, results in the partial separation of the silver as well. The quantity thus obtained is even greater than that of the gold. In 1902 674,000 ozs. were yielded; but the value was only £72,000, as compared with £1,950,000, the value of the 507,000 ozs. of gold that was yielded by all the mines of the colony.

In 1909 800,000 ozs. of silver were produced valued at £180,000.

Coal-Mining.

Since the early days of colonisation in Otago coal-fields have been known to exist. The coal occurs in rock formations that are juvenile compared with the carboniferous rocks of Europe and America. The formation has a wide distribution throughout New Zealand, but more particularly near the coast line. so that, with the exception of Wellington, all the large centres of the dominion have local supplies of coal of a quality satisfactory enough for household, and sometimes for steaming purposes. The majority of these local supplies are, however obtained from seams that vary in thickness within small distances, and often pinch out completely.

All types of coal are represented in New Zealand, with the exception of anthracite.

Bituminous coal, or more properly caking coal, occurs in seams of extreme value on the West Coast,

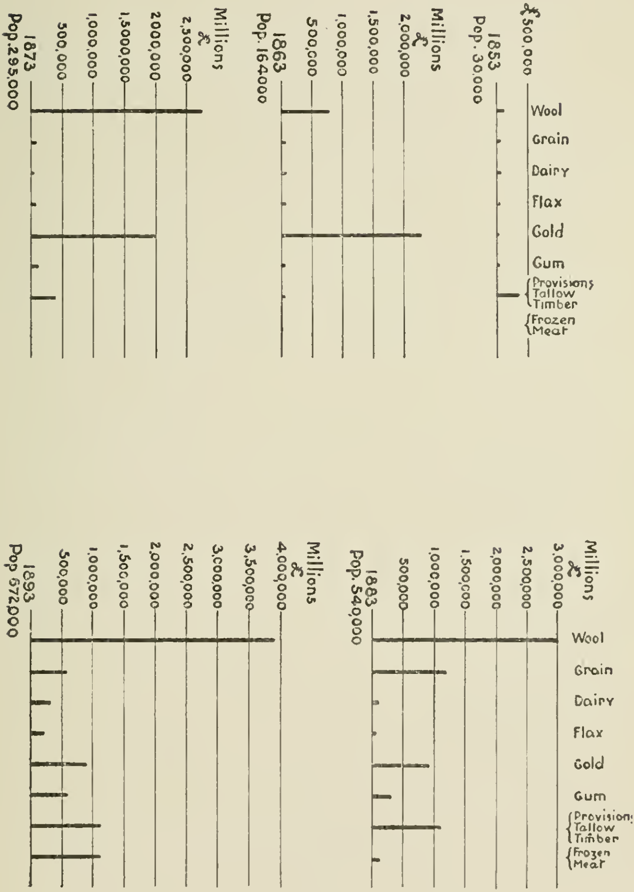
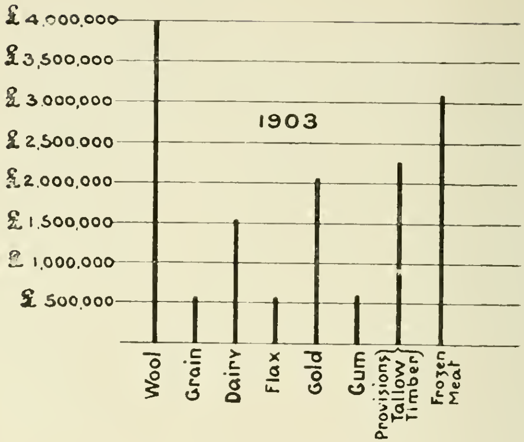


Diagram showing value of chief commodities exported from New Zealand from 1853 to 1893. Continued up to 1909 on p. 318.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1903
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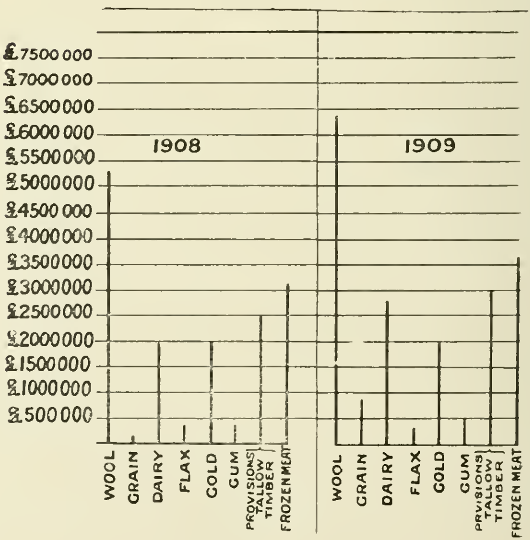
Grain
Dairy
Flax
Gold
Gum
Provisions
Tallow
Timber
Frozen Meat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£500000
1908
1909
WOOL
GRAIN
DAIRY
FLAX
GOLD
GUM
PROVISIONS
TALLOW
TIMBER
FROZEN MEAT

especially at Greymouth and Westport. It is one of the best steam coals known, and is extensively used by the ocean going steamers between New Zealand and England, and large supplies are now required by the Admiralty. The industry of coal-mining would probably attain larger dimensions than at present if the harbours of the district were better. The only two suitably placed are Westport and Greymouth. Both are situated at river mouths, and navigation is much impeded by the presence of formidable bars across the entrances. The New Zealand Government has lately purchased coal-mines in the Greymouth and Westport districts, and the coal used on the government railways is in part mined there.

On the East Coast, the more important coal-bearing areas are at Kaitangata, Nightcaps, Malvern Hills; and in the Auckland district at Huntly, Whangarei, Hikurangi, Ngunguru, and others. In all these places the coal is non-caking, and its quality is vastly inferior to that of Westport and Greymouth. It is really some variety of brown coal, though that obtained from each locality differs in some respects more or less important from that mined in other districts. At Malvern Hills and at Kawa Kawa, the coal is hard and black, with a curved bright fracture. This is pitch coal. At Kaitangata and at Malvern Hills, it is distinctly brown when powdered, and is a fairly typical brown coal. Near Gore and elsewhere, much woody structure is still visible, and the coal is no more than a lignite.

The Westport and Greymouth mines are of far greater importance than those of the rest of the dominion. Not only is the quality of the coal vastly

superior to that of other New Zealand coals, but the quantity is also very great. Thus the coal-mining industry of the West Coast is more permanent and important than that of the gold-mining of the neighbouring goldfields.

The alluvial goldfields made Hokitika, in 1869, one of the largest towns of the district. As the sands and gravels became exhausted, the town was practically deserted, and now Greymouth and Westport, the centres of the coal-mining industry, are also the largest centres of population.

The amount of coal raised in the mines near these two towns amounts to 1,100,000 tons, a total that is far greater than that from any of the other coal districts in New Zealand. In Otago, 288,000 tons, in the Waikato, 192,000 tons, and in Southland 131,000 tons were raised in 1909. The value of all the coal raised was £900,000. The greater quantity of the coal raised is consumed in the dominion; for, of a total of 29,000,000 tons, mined since New Zealand has been colonised, only 960,000 tons were exported, and most of this was used by the ocean going steamers that trade to New Zealand.

Other Minerals.

In value, the **kauri gum** production is greater than any mineral output other than the coal and gold. The gum-digging industry is confined to the northern half of the Auckland Province. It has played an important part in maintaining the prosperity of the province. In 1909, the production was 8,250 tons, of a value of £552,000. This shows a decrease from some previous returns, for in 1899, 11,000 tons were

exported. The decrease is to be accounted for by the exhaustion of some of the better gum-fields. There is, however, still much gum land that is capable of yielding large quantities, so the industry, though likely to show a continual decrease, will for many years remain an important source of wealth to the Auckland Province. Some Kauri gum of inferior quality is obtained from the forks of living trees, and experiments have recently been made in the direction of "bleeding" Kauri trees. The yield of gum procured in this way is said to be considerable, and if the "bleeding" is not performed too frequently, the trees do not suffer any apparent damage. The price obtained for the gum does not vary much from year to year. The average for the last few years is rather more than £65 per ton.

Of other mineral products obtained from New Zealand rocks the **scheelite** of Central Otago is the most important. Its value in 1909 was £4200. The **rock phosphate** from Clarendon is one of the most interesting minerals.

Several other minerals have been mined in New Zealand. **Copper** ore near Nelson, **antimony** ore in Poverty Bay and Central Otago, and **manganese** ore in various places. In Southland a small quantity of **platinum** is obtained from sands and gravels.

The mining of **iron** ores has not yet reached any important dimensions. Ores, however, exist in considerable quantity, particularly near Collingwood and in the vast deposits of black sand extending along the greater part of the West Coast. Works for the treatment of this sand were erected at Onehunga, but did not prove commercially successful.

Greenstone, or nephrite, is obtained in considerable quantity in the river gravels of Westland. It is largely used in making ornaments.

Fruit Growing.

A great variety of fruit can be grown in different parts of New Zealand. In the south, the small fruits of Europe produce large crops, and in the extreme north bananas and oranges will ripen. In all parts of the dominion apples, pears, and the other fruits of temperate climates can be produced in abundance.

In spite of these facts, the fruit industry of New Zealand has not yet attained any great importance. This is due to the want of suitable markets. Attempts have lately been made to ship apples to England, and some canneries have been established.

The localities best suited for fruit growing are Central Otago, Nelson, Napier, and Auckland. In the first the mountain valleys have a hot summer sun that ripens fruit to perfection. The establishment of canneries and the completion of railway communication may yet raise the industry in this region to a position of prime importance.

In Auckland it is now understood that much of the poor clay land hitherto considered almost useless is well adapted for fruit growing. Even vines flourish in it. The results obtained in the Government experimental stations in such land indicate the probability that fruit growing and canning and wine manufacture may become industries of great importance in districts that have previously produced nothing more than a small quantity of Kauri gum.

The fruit industry is of prime importance in the "Cook and other islands." Oranges, bananas and pineapples are exported in large quantity to the main islands of New Zealand. In addition, copra, the dried white albuminous matter of the coconut, is an important product of nearly all of the islands, and some quantity of coffee is exported. The value of these products exported reaches an annual total of £67,500.

Timber.

The **kauri tree** (*Dammara australis*) supplies timber that is easily worked, and has a good even grain and remarkable lasting properties. The tree attains larger dimensions than any other in New Zealand. The trunks are occasionally 25 feet in diameter, and are always cylindrical, and unbranched to a considerable height above the ground. The kauri does not, under natural conditions grow south of 39° S. latitude, so the important industry of kauri milling is confined to the Auckland province. The saw mills employ some 2,000 men and produce £750,000 worth of timber annually. The tree grows but slowly, and there are no areas of immature forest to take the place of those destroyed, so unless great precautions are taken to cut only those trees fully mature, and to preserve the younger ones, the Kauri timber milling industry cannot maintain its present importance for more than two decades.

Other kinds of trees are largely cut into timber for local purposes. The most valuable is the **totara** (*Podocarpus totara*), whose timber is extremely durable. It has been much used for wharf piles and telegraph poles. Although it occurs throughout New

Zealand, it seldom forms forests without admixture of many other trees, and it is now rather scarce. The North Island Trunk Railway has recently opened up important totara forests in the upper basin of the Wanganui River.

The **white pine** (*Podocarpus dacrydiodes*) has a white timber possessed of very poor lasting qualities, but it has recently been found peculiarly suitable for the manufacture of butter boxes, so white pine forests have become valuable in consequence of the rapid extension of the dairying industry.

The **rimu** or red pine (*Dacrydium cupressinum*) grows in forest lands throughout New Zealand. It is used for building in all the southern provinces, though it does not last so well as many other timbers. Several other pines are converted into timber in various districts, but none have very general importance. The native **beeches** (the birches of the settlers) cover large areas of mountain lands with unbroken forest. There are several kinds, and some of them attain a majestic size. Their timber is generally poor, and little used where any other is available. Many ornamental woods can be obtained from the New Zealand "bush." Some of them are used by cabinetmakers in the manufacture of furniture. The "**honeysuckle**" (*Knightia excelsa*) is especially well known for the handsome mottled wood that is obtained from it.

The principal centres of the timber industry are:—

Hokianga Dargaville Whangaroa Mercury Bay	kauri.	Taumarunui district.	totara.

Various small townships in Taranaki	mixed timber.
Rangataua and other stations on the North Island trunk line	
Various small townships in Upper Wairarapa and on Hunterville line	
Havelock in Pelorus	
Kakaramea and other small ports in W. Nelson	
Greymouth	
Hokitika	
Oxford	
Riverton	
Waikawa	

Dairying.

Of all New Zealand industries that of dairying has shown the greatest progress in the last few years. The export of dairy produce has been a New Zealand industry for fifty years, for even in 1853 its value was £12,000. Progress was for a long time slow, for in 1895 the total value of exports was only £375,000. In 1902, the value showed the astonishing increase to £1,450,000. The actual increase is but little less than that of the frozen meat trade within the same period, but while this amount represented only a doubling of the meat export, the increase in dairying has raised the value of the exports to four times its amount in 1899. In 1909, the value rose to £2,750,000.

This development is due to the improved methods that modern advances have rendered possible for the shipment and conveyance of butter. The system of government grading, which has caused uniformity of quality, has materially aided in raising the prices obtained for New Zealand butter, and this has made

dairying more remunerative than ordinary pastoral occupations.

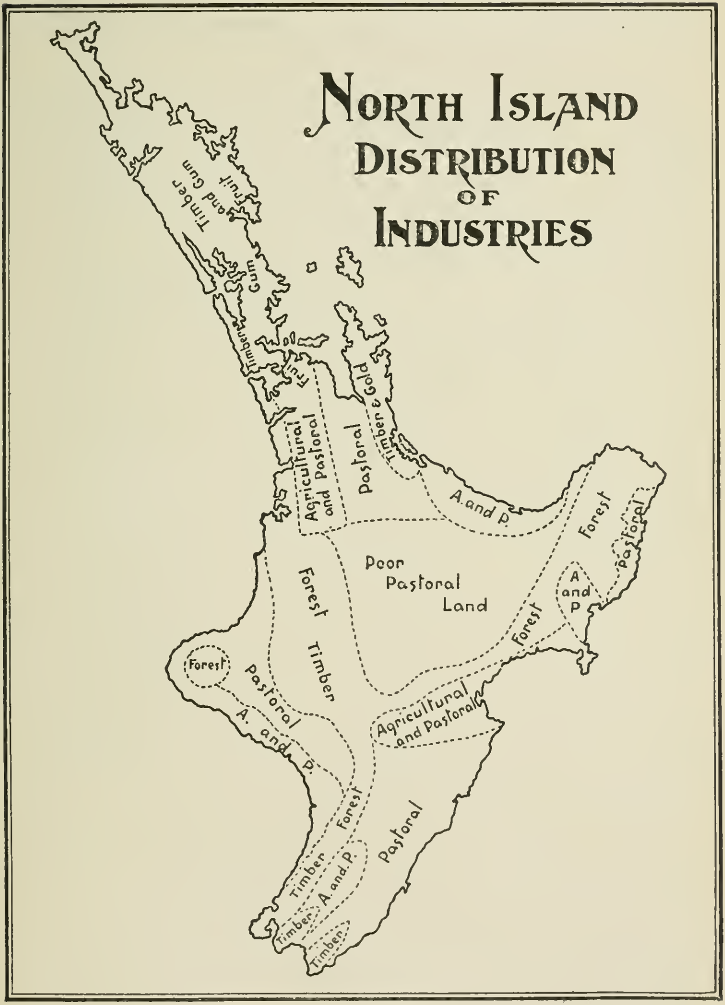
Land that is not very suitable for sheep-farming because of a too heavy rainfall and wet soil is admirably adapted for dairying, so that much of the old bush land is now occupied by dairy farms.

The principal dairying district of New Zealand is Taranaki, where the export was valued at £900,000 in 1909. Here, as well as in the Wellington Province, much land that was formerly used for sheep-farming is now used for dairying. In the Auckland Province, Ngaruawahia is the chief centre of the dairying industry, though in the Manukau and Cook districts there is much activity. At the head of Hawke's Bay province, near Woodville and Waipawa, and in the neighbouring parts of the Wellington Province, Pahiatua, Eketahuna, and Masterton, and from the borders of Taranaki southwards to Otaki, dairying is of great importance.

In the South Island there is not so much dairying land, so the industry cannot compare in importance with the pastoral and agricultural industries. Still at Nelson, and in Canterbury, the Selwyn and Banks Peninsula districts, and in the various east coast districts of South Canterbury and Otago, especially in Otago Peninsula and in Southland, many creameries are in full working, and the productiveness of some of the land has been enormously increased by the success of the industry.

NEW ZEALAND "FLAX" (*Phormium tenax*).

This plant is altogether different from that which supplies the fine fibres from which linen is made. Botanically it belongs to the order of lilies. The long


NORTH ISLAND
DISTRIBUTION
OF
INDUSTRIES
Timber and Gum
Fruit
Gum
Timber
Fruit
Agricultural and Pastoral
Pastoral
Timber & Gold
A. and P.
Forest
Pastoral
Poor Pastoral Land
A and P
Forest
Forest
Timber
Forest
Pastoral
A. and P.
Agricultural and Pastoral
Forest
Pastoral
Timber
A. and P.
Timber
Timber

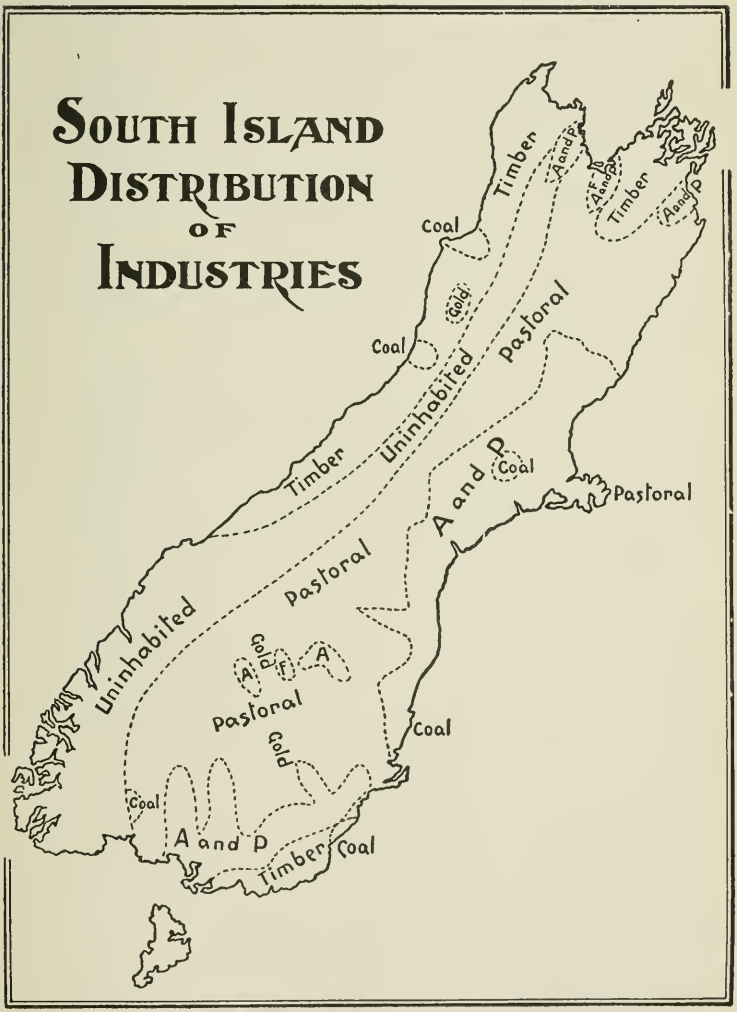
sword-like leaves contain a strong but coarse fibre, which is used for the preparation of binder twine and some kinds of cordage. Much difficulty is experienced in separating the fibre from the other vegetable matter of the leaves, and the imperfect separation has had serious effects on the price obtained for the fibre. The export of "flax" was established in the very early days of colonisation, when New Zealand was still an appendage of New South Wales. The amount has varied enormously in different years: in 1855, 150 tons; in 1861, only two tons; in 1873, 6,500. The following statistics give some idea of the variation:—

1855	150 tons.	£ 4,674
1861	2	43
1873	6,454	143,799
1879	445	7,874
1890	21,158	381,789
1895	1,806	21,040
1902	20,852	534,031
1907	28,547	832,068
1909	14,318	306,973

The value of the export in 1907 was greater than in any other year as the war in the Philippines reduced the output of manila.

All the fibre exported is now graded by a government expert, and the more uniform quality thus ensured has had a considerable influence in raising its value. It is not yet certain that all the requirements of the London buyers are satisfied by the quality of the fibre exported.

The plant grows readily in all parts of New Zealand on hills and in swamps. Much land


South Island
Distribution
of
Industries
Timber
A and P
A F
A and P
Timber
A and P
Coal
Gold
Pastoral
Coal
Uninhabited
Timber
A and P
Coal
Pastoral
Pastoral
Uninhabited
Gold
A
F
A
Pastoral
Gold
Coal
Coal
A and P
Timber
Coal

originally covered with a dense growth of flax has been converted by burning and draining into pasture and agricultural land. The export has hitherto been derived entirely from natural growths, and large areas have been destroyed in gathering the foliage. The plant grows readily when cultivated, but its foliage cannot be cut for two years after planting. The uncertain demand for the fibre and great fluctuation of price have hitherto prevented attempts at cultivation to provide a regular supply of definite quality.

Fisheries.

But little fishing is done on the New Zealand coasts, except what is required to supply the local markets. There is, however, an abundance of edible fish, which are caught by netting, hook and line, and trawling. The sole and flounder amongst flat fish, the mullet and schnapper of the north, the kingfish and blue "cod" of the south, are the best known. The last is caught with hook and line in large quantities at Stewart Island, and after being frozen is exported to Melbourne, where there is always a large demand. The small settlements at Oban, Stewart Island, and at Moeraki, Otago, are the only ones whose existence is so intimately connected with a fish export trade.

Large quantities of whitebait are caught in the spring at the entrances of many streams and rivers, and a canning factory exists on the Waikato River. Mullet is tinned at a factory in Kaipara Harbour. Oysters are obtained abundantly on the rocks in the quiet waters of the inlets of the east coast near Auckland, and mud oysters are dredged from the waters of Foveaux Strait.

One of the most curious industries is the export of **fungus**, small quantities of which are gathered from the trees, chiefly in the Taranaki district. It is exported to China, and the annual value is about £10,000.

The **probable permanence** of the industries named above cannot be asserted in all cases, though the more important of them show great vitality, and give indications of further extension as settlement advances. The exports of kauri gum, timber, alluvial gold, and native flax cannot be maintained for any great length of time. The deposits of kauri gum and alluvial gold have been gradually stored up by natural processes during inestimable lapses of centuries. No appreciable replenishment of these stores can be expected during the short period of human experience. Hitherto scientific forestry has been neglected. All trees that will produce marketable timber have been felled, whether their best development has been reached or no. Few attempts have been made to plant waste lands with timber trees, so no new forests are growing up to take the place of the native bush that is destroyed. The uncertain demand for Phormium fibre has prevented any steps being taken to maintain a definite supply of this substance by planting, and the areas covered by a natural growth of the plant are gradually being diminished.

On the other hand, agricultural and pastoral industries are capable of great extension, and their importance will grow as more lands are opened up and settled. The climate and soil allow of high yields of good quality, and these are essential to enable New

Zealand to compete in the London markets with the similar produce of other countries that are not so far distant.

The system of government inspection and grading that is adopted in the meat and dairying industries might perhaps be extended with beneficial results, for the official brand certifying uniform quality ensures a higher and less fluctuating price.

The fruit-growing industry and wine manufacture are capable of great expansion, but the market for fresh fruit is limited. Greater attention to methods of culture and a realisation of the necessity of growing only those varieties of fruit that have been proved to be suitable for preserving must be impressed upon growers before any great success in fruit canning is to be expected.

Chapter III.—WATER SUPPLY.

The quantity of water needed for the successful occupation and development of a country depends upon the density of the population, as well as on the pursuits and industries that the inhabitants follow and establish.

In rough, mountainous districts a pastoral occupation is followed by all the inhabitants. Since they are few, and the stock maintained by them can travel considerable distances in search of water, the supply in such districts may be comparatively small without interfering in any marked manner with the livelihood of the people. In such districts, however, the rainfall must be sufficient to promote a thick growth of

vegetation in order that the full productiveness of the country should be realised. In those places where mining industry is followed, a large water supply is needed.

In the flatter land, where rich soils have accumulated and agriculture is the chief industry, the population will be more numerous, and a larger water supply is desirable. A rainfall of some regularity is necessary to promote the growth of the crops, but a dry season is desirable whilst they are being harvested.

In the centres of population a constant water supply of pure quality is necessary. This is distributed from house to house by artificial means. The water may be derived from great distances by natural processes or artificially, so the necessity for a large supply does not imply that a heavy rainfall in the centre of population is desirable.

Many industries and manufactures are now worked most satisfactorily by the aid of electricity. Electricity is most economically generated by the use of water power. It is therefore desirable, and probably will be still more desirable in the future, for manufacturing communities to have access to large and constant water supplies that can be used for generating electrical power.

New Zealand is particularly well favoured so far as water supply is concerned. In all parts of the colony the rainfall is sufficient to allow of pastoral pursuits. In a few of the southern districts such as Central Otago and the Mackenzie Country, some of the winter rainfall falls as snow. This necessitates the temporary abandonment of some of the higher

country, and at times causes loss of numbers of stock when the snowfall is particularly early or more than usually heavy. Floods in pastoral country sometimes cause loss of stock, but this is usually most severe in the flatter agricultural country, where the stock cannot so easily climb elevations beyond the reach of the flooded waters.

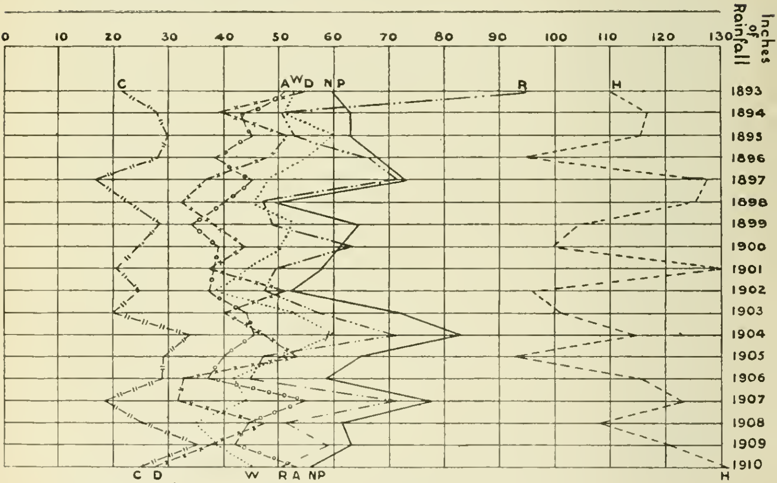


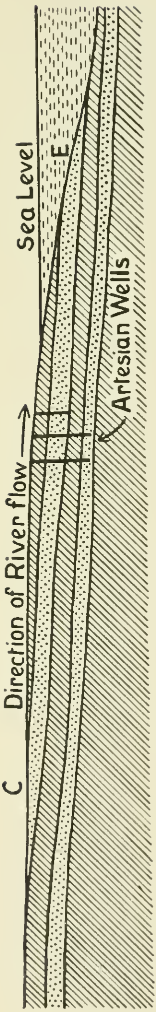
Diagram showing inches of rainfall from 1893 — 1903 at Auckland -o-o-. Rotorua -----. New Plymouth ——. Wellington ······ Hokitika ------. Christchurch -"-"-. Dunedin -×-×-.

The agricultural land in the North Island is chiefly in the Waikato, Hawke's Bay, Wairarapa, and West Coast areas. In all of these districts the water supply is in ordinary seasons quite sufficient to produce a good growth of the crops. On the Wanganui Coast the rainfall is often too great for the most successful development of some cereal crops. This causes an inferior quality of grain to be produced in some seasons.

In the South Island the chief agricultural districts are the Canterbury Plains, North Otago, and Southland. In the first of these the rainfall is comparatively small, and the surface streams are too few to supply the needs of a dense agricultural population. The natural water supply can, however, be supplemented by artificial means. The slope of the surface of the plains is so great that water will run freely down it. The rivers that enter the plains are therefore tapped by artificial channels in their upper portions, and the water is led through a series of branching water-races throughout the plains. Thus, all the small holdings are supplied with perennial streams.

In some parts of these plains, especially near Christchurch, and in other districts of New Zealand, notably in the Hutt Valley, Wanganui, Blenheim, and near Napier, **artesian wells** are sunk. These are metal pipes with pointed and perforated ends that are hammered vertically into the earth until water rises through them. The cause of the rise of water can be easily understood when the geological structure of the plains is known. They are formed of a series of beds of gravel and clay sloping very gently towards the sea, but rather more steeply than the surface of the plains.

The rivers running over the edges of these beds leak into those of gravel *C E* (p. 336) and the water runs through the gravel and finally issues into the sea. In flowing through the gravel the water loses much of its energy by friction against the particles of gravel. If it is tapped at any point intermediate between its inlet and outlet, it will possess more energy than at its point of outflow into the sea, that is, it will rise to a



greater height than the sea level. The water will not rise to the level of the spot where it originally sank into the gravel, despite the truth of the statement that water always finds its own level, for this is only true when the water flows in a closed circuit. In this case the circuit is not closed, for the water is free to issue from the lower end into the sea. The height to which it will rise is, therefore, a measure of the friction that the water encounters between the point where the artesian pipe taps it and the point where it is free to enter the sea.

In Christchurch there are several "water-bearing strata," or gravel beds. From the upper one the water now barely reaches the surface. From the lowest it will flow from an orifice twelve or fifteen feet above the surface. The occurrence of artesian wells at Wanganui and elsewhere is to be explained in a very similar way. It will be noticed that in New Zealand these wells occur only in districts where alternate beds of gravel and clay have been deposited by rivers.

In the small plains of Central Otago (Clyde, etc.) the rainfall is not sufficient to allow of the successful growth of fruit, etc., for the production of which the climate is peculiarly suitable. It is

probable that some arrangement of water races similar to that of the Canterbury Plains will have to be employed.

The **water supply** for the large **towns** and centres of population in New Zealand has been provided without any great trouble. In general, the difficulties that have been encountered have not been a result of any scantiness in sources of supply, but rather consist in deciding upon the best of many sufficient and satisfactory sources.

The majority of the towns have drawn upon lakes or streams in their immediate surroundings. In most cases where streams have been utilised, dams have been thrown across them, and the water has been derived from the small lakes they artificially formed; the distribution has in most cases been effected by gravitation, for the dams have been made in localities at a higher level than the towns that have to be supplied with the water.

The rapid growth of some of the larger centres has made it necessary to increase the supply from time to time, and to seek larger and usually more distant streams, whose water would not be liable to local contamination.

In Auckland the first supply was obtained from a stream flowing from a swampy area now occupied by the Domain cricket ground. The insufficiency of this supply was soon demonstrated. Recourse was then had to the Western Springs, three miles distant from the town. The springs are at the sea level, and the water was pumped to storage reservoirs at various points of high level. As the population and consequent demand for water grew, it was found

that the drainage area of the springs was becoming polluted by the increasing population, and at the same time the outflow from the springs was insufficient.

Streams in the Waitakerei ranges have now been utilised and water is drawn from dams situated ten miles away.

Similar changes have been made in the water supply of Wellington and Dunedin, and on a lesser scale in many other towns.

Christchurch occupies a unique position amongst the largest towns of New Zealand in the matter of water supply, for in addition to a general high pressure water supply for the town many householders have artesian wells from which the water is raised to the upper stories by a hydraulic ram or windmill. The supply from the artesian wells is invariable, but as the number of wells increases, the height to which the water rises becomes gradually less.

Lyttelton is supplied by water that is pumped from artesian wells driven near the entrance from the plains to the tunnel that pierces the Port Hills and connects Lyttelton and Christchurch.

Advance in the construction of electrical machinery has caused manufacturers to look in various directions for **water power**, which can be more economically utilised than steam power for generating an electric current. Nearly all parts of New Zealand offer splendid opportunities for electrical stations of this nature. The heavy rainfall, steep mountainous country, and precipitous rocky gorges together combine to produce excellent conditions of

advantage unequalled in any other part of Australasia, for the installation and use of electrical power. Hitherto little use has been made of this source of abundant wealth and prosperity. Signs are not wanting that in the near future the use of the electric dynamo will largely replace that of the steam engine in most of the industries of the country.

The Huka falls on the Waikato River, the gorges through which the Canterbury rivers issue from their mountain fastnesses, and the waters of Otago have lately been subjected to close and critical examination by electrical experts with a view to their future utilisation, and it is probable, that, before long, some or all of these may be made to yield up for human use some of that vast amount of power that is now running to waste. The Horahora falls on the Waikato River are now being harnessed by the Waihi Gold-mining Company. The Government has committed itself to a comprehensive scheme for supplying electrical power to the larger centres, and works have been begun at Lake Coleridge to supply Christ-church. The Dunedin City Council derives 6000 electrical horsepower from the Waipori river.

Chapter IV.—MANUFACTURES.

All the important exports of New Zealand consist of raw materials, or of materials that have been so far prepared as to enable them to reach the European market without undergoing deterioration. The amount of manufactured material exported is very small. Exclusive of phormium and leather, the total

in 1909 was little more than £160,000 in value, and of this woollen manufactures totalled £8,000.

There is a considerable amount of material of home manufacture consumed within the dominion. The amount of **woollen** material, for example, was valued at £450,000 in 1905, an amount almost equal to the value of the imported woollens. The most important of the woollen mills are situated at Petone, Kaiapoi, and Mosgiel, but there are many others. Some 1,600 hands are employed, and in the clothing factories that deal with the output there are 2,500 employés.

The **boot** factories produce an output of a value of £500,000, an amount that is not twice as great as the value of the imports. The tanning of the leather for this manufacture gives employment to 1,300 people, and the value of the output from the tanneries is £1,800,000. Much of this is exported for use in European factories. The tanneries and boot factories are equally distributed in the larger towns of the dominion.

Many other materials of ordinary use are manufactured in the dominion. Chemical factories, iron and brass foundries, biscuit, saddlery and harness works, coach building, sugar refining, agricultural implement works, and breweries are all of considerable local importance, but none of the articles made therein are exported in any quantities from the dominion.

The factories are almost without exception situated in the larger towns, whose wants they supply. Hitherto steam power has been used in them almost without exception, and it is probable that their location in the towns, generally at some distance

from the more important coal districts, is caused by the convenience of being situated near the markets, whose immediate necessities they have to supply.

The government of New Zealand has now become alive to the great importance of the enormous power at present going to waste in the various rivers of the dominion. These have steep, narrow valleys, and flow from regions of abundant rainfall. If these sources of power were utilised, and a cheap and efficient conversion scheme instituted, electricity would probably supersede steam power in all parts of the dominion. The cost of manufacture would then be less, and New Zealand might ultimately become an important manufacturing country. A start in this direction has already been made, as has been outlined above, and it is hoped that the use of cheap electrical power in the larger centres will greatly increase the amount of material annually manufactured.

Chapter V.—TRANSPORT AND COMMUNICATION.

The long coast line of New Zealand, and the position of the earliest settlements on secure harbours naturally made the method of communication by sea most easy and satisfactory. Sailing vessels of small size were at first used, and on the stormy, partially surveyed coasts many dangers were encountered. Overland journeys were seldom undertaken, partly because of the rough nature of the country, the dense, almost impenetrable forests,

and sometimes because of the hostile attitude of the natives.

Roads were generally formed near the larger settlements, but the hilly nature of the country at Auckland, Wellington, and Dunedin made their construction slow and expensive. The only communication between Christchurch and its port was for fifteen years a long, steep road over the Port Hills.

The rivers of New Zealand are for the greater part not navigable, but the Wairoa River, the Thames, Waikato, and Wanganui provide rather unsatisfactory channels, along which portions of the back country can be visited, though vessels of any but the smallest draught cannot proceed far from their mouths.

Railways.

The perishable nature of much of the New Zealand produce has emphasised the necessity for rapid transport to the ports where it can be shipped. The welfare of the country depends to no small extent upon the efficiency of the railway service which provides for this transport.

In the early days of settlement, especially in the North Island, where the timber and phormium that were the chief articles of export grew close to the shores of streams and deep-water harbours, the necessity for railways was for some time not apparent.

In the Canterbury settlement, where the farming produce had to be collected from wide areas and transported from Christchurch to Lyttelton, the need of railways was evident. In 1863 the first New

Zealand railway was opened at Christchurch, and in 1867 the tunnel, 1¾ miles long, through the Port Hills—really the rim of a volcanic crater—was completed, and trains took produce direct to the wharves at Lyttelton. In the meantime other lines had been completed, connecting various country districts with Christchurch. Invercargill and Bluff had been connected, and a line laid between Auckland and Onehunga, and onwards to Drury. By the year 1870 some fifty miles of railway were completed, but from that time onwards construction was far more rapid.

The Auckland line was carried southward into the middle Waikato basin. New Plymouth, Wanganui, Napier, and Wellington became centres of railway formation, but for a long time there was no connection between the lines formed at these places. The New Plymouth section extended to Hawera, the Wanganui section from Patea to Foxton, the Napier to Woodville, and the Wellington section to Masterton. It was not until after 1887 that the section between Hawera and Patea was formed, and in 1885 a private company—the Wellington-Manawatu*—united Palmerston to Wellington, so that through traffic was established from Wellington to New Plymouth. Afterwards Palmerston and Woodville were joined by a line that passed through the steep gorge of the Manawatu River. Lastly Woodville and Masterton were connected, and all the important centres of population of the southern portion of the North Island possessed railway communication. In the meantime the Auckland line was pushed further south, and has now been united

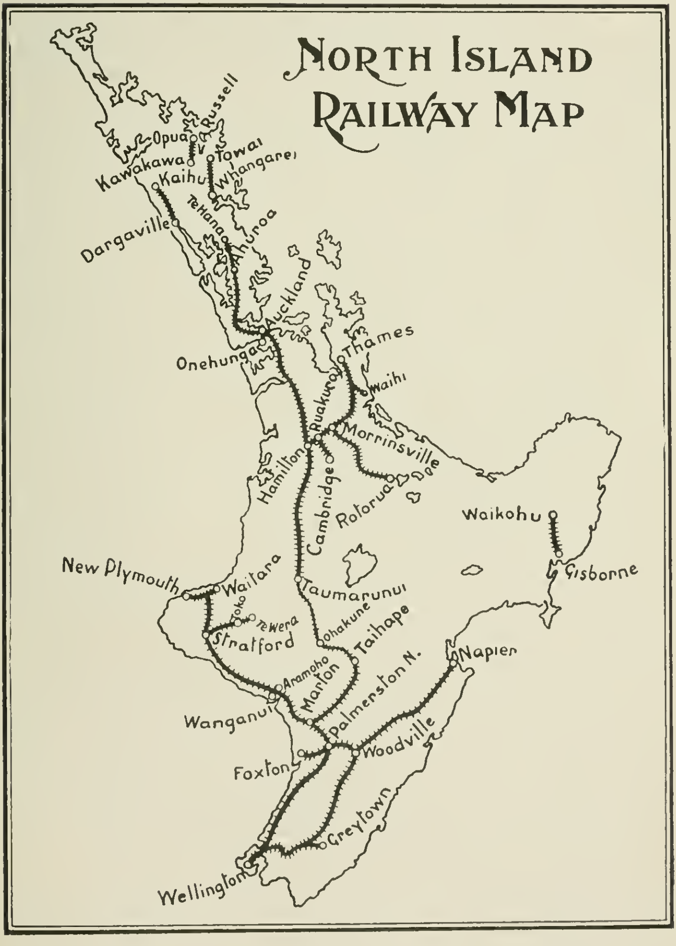
* Purchased by the Government in 1908.

to the line that, leaving the west coast line at Marton, passed round the southern base of Ruapehu and now forms the Main Trunk line of the North Island which unites Auckland and Wellington.

Railway construction has been completed for seventy-five miles to the north of Auckland in continuation of the main trunk line, and will ultimately connect with the short line to Dargaville, and with the Whangarei and Kawakawa line. Branches leave the trunk line in the middle Waikato basin and extend to Thames and Rotorua. It is now intended to extend the Paeroa-Waihi line to Tauranga, and to unite the Gisborne line with Napier and to extend it northwards to the Bay of Plenty.

The construction of these lines has generally succeeded settlement, and commencement of formation was made in the larger centres, and as has been shown, they were gradually extended as settlement progressed and closer commercial relations were required. No engineering difficulties of specially great magnitude have been encountered, though for a long time the precipitous nature of the Manawatu gorge prevented the construction of the connecting link between the East and West Coast systems; and the construction of large viaducts, especially that of Makohine, delayed the construction of the Trunk Line. The line to Rotorua passes over country 1900 feet above sea level, and the main trunk line reaches to 2660 feet at Waiouru. The construction of this railway, in conjunction with feeding roads, opens much farming land, and adds greatly to the progress of the North Island.

The less formidable difficulties in the East Coast

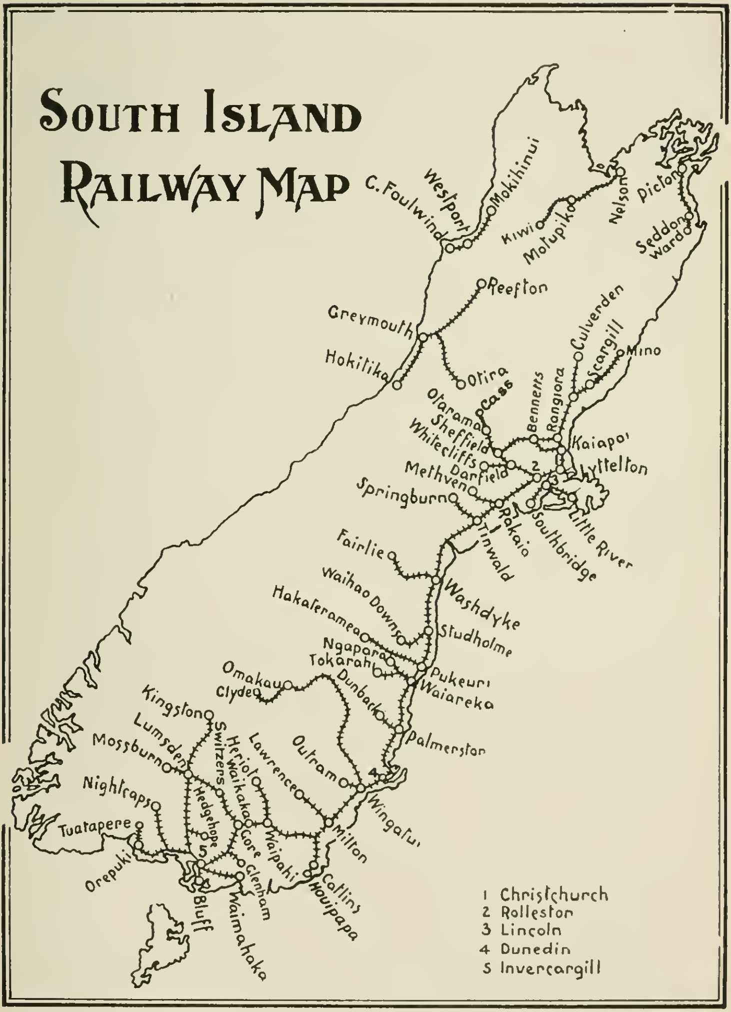

North Island
Railway Map
Russell
Opua
Kawakawa
Towai
Whangarei
Kaihu
Dargaville
Te Hana
Ahuroa
Auckland
Onehunga
Thames
Waihi
Ruakura
Morrinsville
Hamilton
Cambridge
Rotorua
Waikohu
Gisborne
New Plymouth
Waitara
Toko
Te Wera
Stratford
Taumarunui
Ohakune
Taihape
Aramoho
Marton
Palmerston N.
Napier
Wanganui
Woodville
Foxton
Greytown
Wellington

districts of the South Island, and the more rapid progress and increase of settlement rendered railway construction more rapid, and the Main South line from Culverden to Riverton was completed much earlier than any of the larger of the North Island lines.

A private company was empowered by the Government in 1887 to construct a line between Nelson and Christchurch *viâ* the West Coast. After much litigation the company's lines, despite vigorous protest, were taken over by the Government and their construction is still in progress. The mountain chain of the Southern Alps interposes a formidable barrier, and the long tunnel required to pierce the main axis was commenced in 1909. Greymouth, Reefton, and Hokitika have been connected, and the eastern ranges of the Southern Alps are now being penetrated along the gorge of the Waimakariri River. The West Coast lines connect the highly important coal and gold mines with the ports of the coast. From Nelson a line extends southwards 48 miles towards Reefton.

Various branch lines connect the interior centres with the Main South line. Two of these that unite at Lumsden connect Lake Wakatipu with the coast district, and the Otago Central line extends from near Dunedin into the pastoral and fruit growing districts of the broadest portion of the island.

There are now (1910) 2717 miles of railway open for traffic: 1144 in the North and 1573 in the South Island. The lines have the uniform narrow gauge of 3ft. 9in., so travelling is comparatively slow, and


SOUTH ISLAND
RAILWAY MAP
C. Foulwind
Westport
Mokihinui
Kiwi
Motupiko
Nelson
Picton
Seddon
Ward
Reefton
Greymouth
Hokitika
Otira
Culverden
Scargill
Mino
Cass
Otarama
Sheffield
Whitecliffs
Bennetts
Rangiora
Kaiapoi
Lyttelton
Methven
Darfield
Springburn
Rakaia
Tinwald
Southbridge
Little River
Fairlie
Washdyke
Waihao Downs
Studholme
Hakateramea
Ngapara
Tokarahi
Pukeuri
Waiareka
Omakau
Clyde
Dunback
Kingston
Palmerston
Lumsden
Switzers
Heriot
Lawrence
Outram
Mossburn
Waikaka
Nightcaps
Hedgehope
Wingatui
Milton
Tuatapere
Gore
Waipahi
Orepuki
Glenham
Catlins
Bluff
Waimahaka
Houipapa
1 Christchurch
2 Rolleston
3 Lincoln
4 Dunedin
5 Invercargill

many short curves and steep grades exist. They have been constructed and equipped at an average cost of £10,544 per mile. In Queensland, where the gauge is the same, the cost has been £6793 per mile. The passenger fares and freight are fixed at such a figure that the returns give net profit equal to 3.80 per cent. on the cost, for the railways are regarded as constructed for the development of the country, not as a source of revenue to be applied to other uses. The present yield is lower per mile than the yield of railway revenue of any of the Australian States with the exception of Tasmania and Queensland.

A tourist department has recently been established. It is recognised by the Government that the extraordinary variety of scenery to be found in New Zealand, as well as the trout fishing and deer shooting, offer great attractions to tourists of very varied tastes. The department has made every endeavour to popularise the most accessible and attractive resorts, and to organise the accommoda-tion and communication so as to increase the comfort of the tourists that visit the country.

The magnificent fiords of the south west, the grand scenery of the cold lakes of Otago, the great glaciers of Mount Cook, the forest and river scenery of the Wanganui, and the wonders of the hot lakes can all be visited with ease and convenience.

The construction of **roads** and bridges is being pushed forward with energy, but there are still large districts practically isolated. New necessities arise as settlement progresses, and in the bush land in particular great difficuty is experienced and expense

incurred in constructing roads. The northern peninsula of Auckland is practically roadless. The eastern part of Taranaki and the Wanganui Coastal Plain have crying needs, and on the West Coast of the South Island roads are very few. This want of roads is felt most acutely in the dairying industry, for daily communication is necessary in all weathers between the farms and the creameries, and easy access from these to the butter factories. In the pastoral districts roads are not so vitally necessary. The sheep can be driven to a suitable shearing station on a road, and the outward transport of wool is often all that is necessary.

In the drier pastoral districts, roads are more cheaply made and maintained than in the wet bush land seamed everywhere by deep ravines, which is usually the character of the land of dairying districts.

Communication between the different parts of the colony is maintained by many steamer services. Of these, that of the Union Steamship Company is the most important. This locally formed company, which has a fleet of 67 vessels, provides a most efficient service between all the more important parts of New Zealand as well as services to Australia, San Francisco, and Vancouver. Its steamers are of large size and well equipped. The Northern Steamship Company maintains a service throughout the Auckland Province and as far south as Wanganui and Opotiki. Numerous shallow-water ports and bar-bound tidal estuaries are characteristic of this area, so small shallow-draught steamers are

employed. Similar but small local companies serve to maintain communication between the bays and large ports elsewhere in the dominion.

Navigation of the New Zealand Coast is often troublesome. During easterly and southerly weather, fogs and drifts lie thickly on the coast, and obscure headlands on which the captains rely for guidance. Lighthouses have been erected on most of the prominent capes and harbour headlands of the dominion. There are now twenty-nine lighthouses distributed along the coast of New Zealand and the islets near it. None have yet been erected on any of the outlying islands, but depôts of provisions are maintained on many of them for the benefit of shipwrecked mariners. The rise and fall of the tide is not very great anywhere on the New Zealand coast. It reaches its greatest amount at the head of Tasman Bay. The larger and more important harbours have water of such depth that they are available for all vessels, even at low tide. Dunedin, however, can be reached by the larger vessels only when the tide is full.

River navigation is not important. Only a few of the rivers are navigable for vessels even of the lightest draught, and where railways are available, the rivers are entirely neglected. All the trade of the rich Waikato district is carried by a railway, which runs for a long distance close to the river. The Wanganui River is used as a highway for shallow-draught steamers that carry the produce of the settlers on its banks and supply them with stores. These steamers also carry a large tourist traffic to the upper reaches of the river.

The New Zealand lakes are situated in districts where there is little settlement and they are unimportant as water highways. There are small steamers on many of them, but they are more dependent on the custom of tourists than on any returns from settlers' produce.

There are two cable **routes** between New Zealand and Australia. The more direct is owned by the Eastern Extension Company. Its terminal station in New Zealand is at Cable Bay, Wakapuaka, near Nelson, and running from here, a cable connects the station with the North Island at Wanganui. Two other cables connect the North and South Islands, one of them crosses from White's Bay to Oterangi, the other to Lyell's Bay. The other cable to Australia was opened in 1902, and has its terminal station at Doubtless Bay in the north of Auckland Peninsula. It connects New Zealand with Norfolk Island, whence a cable passes to Southport, near Brisbane, and also to Fiji, Fanning Island, and to the terminus at Vancouver. This cable belongs to the Pacific Cable Company, but a portion of the original cost and of the deficiency in operation, if any, is guaranteed by the Colonial Governments. Stewart Island is now connected with the mainland by cable.

Within the dominion there are 10,901 miles of **telegraph** lines, so even the smaller towns have the benefit of telegraphic communication.

There are **telephone** exchanges in twenty of the larger towns, and a large number of other centres are connected with these through sub-exchanges.

Postal communication with Europe is maintained by four mail routes. Of these the San Francisco

route secures the quickest delivery. The New Zealand port of departure is Auckland. The steamers call at Papeete and from San Francisco the mail traverses the United States of America by rail and is again shipped at New York. Letters are delivered in London thirty days after the mail steamer leaves Auckland. This service provides the only direct mail route to the United States of America.

Every Monday a European mail (the Federal Service) leaves the Bluff. At Melbourne it is transhipped to steamers of the P. and O. or Orient line, and is delivered in London thirty-eight days after the steamer leaves the Bluff. This route provides New Zealand with a mail service with Asia. Another connection with this mail is made from Wellington to Sydney.

A mail *viâ* Fiji, Honolulu and Vancouver leaves every fourth week, and the letters are delivered in London thirty-two days afterwards. By this route there is direct communication with Canada.

Direct steamers for England leave New Zealand ports almost every week and reach Plymouth in about forty-three days. These steamers are utilised for the parcels mails. Their route is *viâ* Cape Horn and Montevideo, so they carry the mail for South America.

The inward mails to New Zealand occupy the same time in transit and follow the same routes, with the exception of the direct lines, which, in order to profit by the prevailing westerly winds, send their steamers to New Zealand *viâ* Capetown.

Australian mails leave New Zealand from Auckland, Wellington, and the Bluff, altogether two or

three times per week. The greater part of this service is performed by the Union Steamship Company of New Zealand, but the Huddart-Parker line and some of the Ocean lines supplement their sailings. Within the dominion mails are carried by steamer, rail, coach, and even pack-horse to the more outlying settlements. In all the larger towns there are two or more letter deliveries every day. Some of the more out of the way districts receive mails only at long and sometimes irregular intervals. Thus, at Martin's Bay on the West Coast, there is seldom a shorter interval than three months between mail days. Even Gisborne does not receive mails from outside daily, nor do such towns as Greymouth and Hokitika. The great majority of the important townships, however, receive mails from all accessible parts of the dominion every day. There is a daily mail between the North and South Islands carried in steamers running between Wellington and Lyttelton; so that nearly all parts of the dominion can have daily communication with one another.

CHAPTER VI.—ELEMENTS IN COST OF PRODUCTION.

The high **rate of wages** prevailing, and the small number of working hours are by themselves sufficient to render the cost of production high within the dominion. The tendency at present is perhaps to increase the rate of wages, on the one hand, and to reduce the hours of work on the other.

This result is achieved by legislation, and though the material happiness of a large body of the popula-

tion is possibly increased, it interposes a barrier that entirely prevents the competition of New Zealand manufactures in markets outside of the dominion.

The **Industrial Arbitration Act** provides that disputes between employers and employed may be adjusted by a special court. The effect of this Act has been to stop all strikes and so secure a continuity of occupation to those engaged in the various industries. The Arbitration Court has thus to settle disputes in matter of wages during ordinary hours, and for overtime. In practice it has been found that in the great majority of disputes that have been referred to the Court, a rise in the rate of wages has been ordered. In other respects, notably in the number of apprentices and in the remuneration for overtime, the cost of production has been materially increased.

In the other direction the **hours of daily employment** have been limited by direct legislation to eight in most of the industries. All those employed must be given one half holiday in the week. Shops must close for one half day during the week and, in the four large centres, can be kept open later than six only on one evening in the week. This naturally restricts the amount of work that can be performed per man employed, compared with that performed in other countries, where the restrictions are less severe, and thus the cost of production is again increased. But it is contended that the increased leisure renders the worker more efficient during his working hours. **Machinery** used in the industries is nearly all imported and is, therefore, more expensive than in those countries where it is manufactured. Even in

those cases where manufacture is performed in the dominion, the causes previously mentioned operate, and the cost is relatively high.

The cost of **fuel** is high, because in most cases it has to be shipped and unshipped, or is of inferior quality. As all the factories that exist are dependent upon steam for power, the price of fuel increases the cost of production.

The cost of **freight by rail** is also rather high, for the initial expense in constructing the railroads was considerable, because of the engineering difficulties offered by the country through which they pass, and of the high rate of wages given to the workmen. Some of the other causes mentioned operate here also.

The cost of producing **raw material** is, however, quite low. Land has in most cases been easily and cheaply obtained. It is often readily worked, and climatic conditions render the lives of the producers comfortable without much expense being incurred in the erection of dwellings, or stables, or shelters for the stock. There are no "vested interests" of villagers, necessitating their employment on the farms of the landlord. The land can, therefore, be farmed economically with a minimum of labour. Improved machinery is largely employed in farming, and the cost of production of all farm products is relatively low.

A cause that has an effect throughout industrial life in New Zealand, is the low price of **food**, especially meat; but on the other hand, clothing is expensive compared with prices elsewhere.

The general effect of all the influences mentioned is obviously to maintain a high price for all manu-

factured articles, but a low price for the prime necessaries of existence.

If manufactures from other lands were admitted free, none of the New Zealand manufactories could exist. This is considered a matter that must be adjusted by legislation. Consequently a **high tariff** has been imposed on everything that can be manufactured in the dominion except necessaries of life. This has been done partly to foster local industries, partly to satisfy the exigencies of colonial finance, and partly to enable high wages to be given to colonial workmen, and thus save the population of the country from including amongst its numbers any of the absolutely indigent class, whose presence in European towns is such a blot upon civilisation.

Chapter VII.—INTERNAL TRADE.

The manufactures of New Zealand are nearly all produced for the local market, for various factors make the cost of production so high that they are unable to compete with those of other countries in the world's markets. The demand for such articles as are manufactured is, however, small; for the population is little more than 1,000,000 and the demands of such a small number cannot maintain an internal trade of great dimensions.

Most of the **coal** raised is consumed within the dominion. The exports of this article are almost equal to the imports, so the 1,910,000 tons raised, of a value of £950,000 comes fairly under the head of internal trade. Of the **wool** yield of the dominion an

amount of the value of £200,000 is used in New Zealand manufactures, and the **leather** utilised for boot making and saddlery has a greater value.

Soap and candle works require a supply of **tallow.** Of the annual **grain** yield, the amount converted into flour within the dominion is valued at £800,000, and very little of this is exported. Most of the **fruit** that is grown is used locally; the **barley** and **hops** are used in New Zealand breweries; and the supply of **meat** and other necessaries is derived from local sources.

It is impossible to estimate accurately the value of the internal trade, by which a continuous supply of all these commodities is assured.

The principal centres of **internal trade** are the towns with the largest populations. Here the small factories are situated, the wool and grain are bought and sold, and in the towns or their immediate neighbourhood are converted into clothing or bread. In addition saleyards for stock are close at hand, and in these markets the prices given for all commodities locally consumed are fixed by the amount of competition that prevails.

In most cases these prices are primarily based on the prices for the same commodities given in the London market, but there are many local variations from these, depending upon the seasons, climatic changes, the amount offering for sale, and other conditions.

The larger towns are also the **distributing centres** for many of these objects of trade, and from them distribution is effected by rail or steamer travelling to the various districts where demands exist. For

some of these commodities, each little centre of population is its own market and its own distributing centre; but in such cases the prices given are based upon those that prevail in the larger towns.

In the matter of the **market for coal** and its distribution, the West Coast towns have almost a monopoly. The prices offered are partly dependent on the value of coal in Australia and its prices when delivered in New Zealand. The superior quality of some of the New Zealand coal enables it to find buyers at a price slightly above that given for coal from Newcastle or elsewhere. The distribution is effected by steamer traffic to the larger ports of the dominion, whence it is railed to the minor centres. No attempts have yet been made to establish large factories in the coal districts so that the West Coast ports may become the centres of general trade.

Chapter VIII.—EXTERNAL COMMERCE.

While raw and manufactured materials comprise almost the total exports of the dominion, the **imports** consist almost entirely of manufactured articles. At the present time this commerce is carried mainly by ocean steamers that trade directly between New Zealand and England. On the journey from the dominion they steam *viâ* Cape Horn. On the return journey they steam *viâ* Cape of Good Hope. This change of route is rendered advisable by the preponderance of strong westerly winds in the Southern Seas. There are five lines of direct steamers which collect their produce at various ports. In addition,

sailing vessels carry grain, wool, and timber in considerable quantity. The steamers are all fitted up with refrigerating chambers and machinery, so they can carry frozen meat without injury. They have in addition suitable arrangements for the carriage of dairy produce.

At many of the **ports** there are no deep water berths, and at these places steamers are tendered by smaller vessels while they lie in the open roadstead. This is done at Wanganui and Gisborne. At other ports substantial breakwaters have been erected, and secure deep water berths are thus provided on coasts that previously had only open roadsteads. The best examples are at Timaru, Oamaru, and Napier. In other ports a little dredging has been necessary.

In the Auckland Province cargo is obtained at Auckland, Gisborne, and Dargaville, but at the latter port timber is the chief export and is carried by sailing vessels.

In Taranaki Province, New Plymouth, Patea, and Waipara are the chief ports. From them dairy produce and frozen mutton are the largest exports.

The Hawke's Bay Province has the sole port of Napier. Wellington Province exports from Wellington, and Wanganui.

Nelson Province exports some varied products from Nelson town, and coal from Westport.

Marlborough sends away a small quantity of produce from Picton and Blenheim.

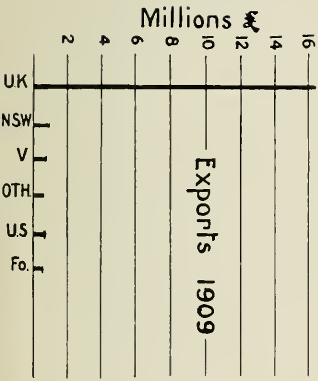
The exports of Westland are coal, timber, and gold from Greymouth and Hokitika.

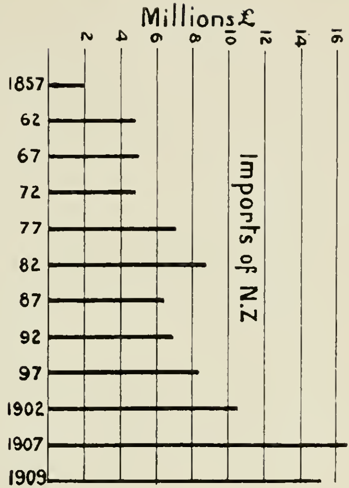
The important volume of exports from Canterbury is sent from Lyttelton and Timaru.

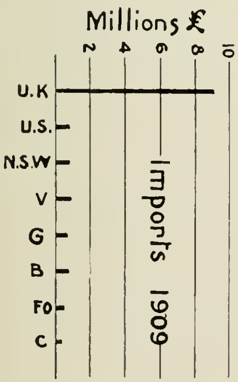
Otago's exports leave from Dunedin and Oamaru, and the Southland port is Bluff.

In 1909 the exports from Wellington exceeded those from other ports and were more than £3,680,000 in value. The exports from Auckland approached closely to the Wellington total, while Lyttelton exported to the value of £2,630,000, and Dunedin considerably less, the last was exceeded by Napier. All the other ports are of minor importance. The produce reaches the ports by the ordinary routes of transport. In Canterbury and Hawke's Bay the railways collect it all from different country districts. The Auckland exports are largely collected by the small steamers that trade to the numerous ports north and south of Auckland and Onehunga on the east and west coasts, and also by rail from Waikato. Wellington's exports are brought by rail from the Wairarapa and the west coast, but their amount is supplemented by the freights of the small steamers that trade with the smaller ports on the coast.

The same ports are the chief centres of the **import trade** and their relative importance is much the same as before, except that the imports to Napier are less than £500,000 in value, not one-sixth of the value of Dunedin imports. The other smaller ports are of much less importance in the import than in the export trade. The difference is caused by the fact, that the direct steamers unload all their cargo at the chief ports. The smaller ports are therefore less important as distributing than as collecting centres of produce for the lading of which the direct steamers call.







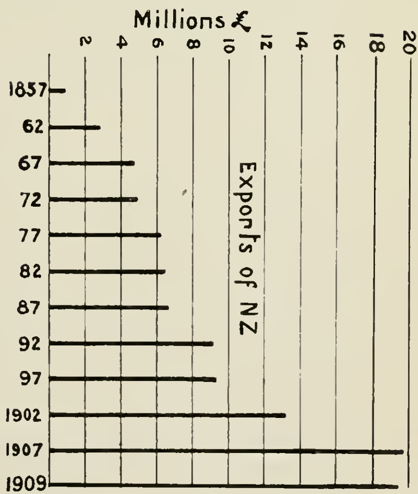


Diagram showing comparative amount of trade with different countries.
U.K.—United Kingdom. N.S.W.—New South Wales. V.—Victoria.
OTH.—Other British Possessions. U.S.—United States.
FO.—Other Foreign Parts. B.—Bengal.
C.—Canada. G.—Germany.

The **value of the exports** averages about £2,250,000 more than that of the imports. The year 1908 was the only year within the last twenty-two in which the imports exceeded the exports in value. The low price of wool was the main cause of this. In 1909 they were £19,463,000 and £16,675,000 respectively.

The **volume of trade** has shown very great expansion within recent years—its present amount is almost double that of 1897, though the population within the same period increased only by one-third. The amount of trade has shown a very constant but gradual increase throughout. There have been but few lean years of depression, when the trade returns were lower than those of previous years. The accelerated rate of increase of recent years must be ascribed to the rapid development of the frozen meat and dairying industries.

Countries affected. The vast majority of our **exports** are sent to England; their value was £16,190,000 in 1909, while only £1,920,000 worth was sent to the Australian Commonwealth, Victoria and New South Wales taking more than nine-tenths of this. The United States takes products of the value of £684,000, and other foreign countries less than £350,000.

The **import** trade is rather differently distributed. The articles obtained from England are valued at less than £9,280,000. From the United States the imports are £1,170,000, nearly twice the value of the exports, and from the Commonwealth £2,700,000, nearly half as much again as our exports. From

other British possessions we import material worth almost £1,500,000, while our exports are worth £530,000. The imports from Germany cost £327,000.

The external trade of New Zealand would be greater but for the effect of the **Customs tariff**. Duties up to 25 per cent. *ad valorem* are imposed on all objects that can be manufactured in the dominion. This has stimulated the internal trade and colonial industries at the expense of the external trade. Were it not for the high cost of production in New Zealand the effect would probably be greater.

The total trade of New Zealand is greater than that of any of the Commonwealth States, except New South Wales and Victoria. In 1903 the excess of exports over imports was greater in New Zealand than in any Australian State.

In 1908 the New Zealand trade with the United Kingdom was greater in volume than that of any of the Australian States.

Chapter IX.—MODERN RIVALRY IN TRADE AS IT AFFECTS NEW ZEALAND.

The more important products of New Zealand are produced in equal or greater quantity in Australia, and also in South America, as well as in European countries. The exports of New Zealand have to enter the English market in direct competition with those of the other countries. The greater **distance** of New Zealand from this market, must, in the absence of unlimited demand, seriously handicap her products in this competition; for communication is more

prolonged, the **freight** charged is higher, and the navigating risks in consequence of the longer voyages are more numerous. The rate of wages in New Zealand is rather higher than that which prevails in most countries with which the similarity of productions brings her into competition. This competition has practically crowded New Zealand out of the English wheat market. It is evident that compensating advantages are necessary in order to prevent the complete destruction of New Zealand trade, by rivalry that possesses the advantages of comparative proximity to the central market and of lower rates of wages.

In comparison with Australia, the more constant and favourable **climatic conditions** render the quantity of all commodities produced less subject to annual variation and more uniform in quality. The average production of the land is also greater.

The more **stable form of government** gives New Zealand a great advantage over the Argentine Republic, which is a very formidable rival. The large area of land suitable for sheep farming and agriculture gives the Republic a producing power that enables it to swamp New Zealand products in the European markets. In competing with this rival, it is necessary for New Zealand to maintain a high standard of export that may secure a ready sale, even when the market is crowded with similar but inferior products of other lands. This has hitherto been accomplished with some success by the system of **government grading** of New Zealand produce. Our government brand ensures a definite quality for each grade of produce.

In many articles the competition of European countries is less felt because of the **difference of seasons** in the Northern and Southern Hemispheres. Thus the dairy and farm produce arrives in London when the supply of such commodities from northern countries sinks to its lowest amount.

The necessity for the maintenance of **unimpeded traffic** over the ocean highways is of prime importance to New Zealand. Dependent as we are upon the speedy arrival of our produce in Europe, any influence that might retard its passage or render its transport unsafe would at once destroy the prosperity of the country. Thus it is imperative to New Zealand that the power and supremacy of the British Navy should be fully maintained. At present, the money contributed to the upkeep of the navy by the dominion is insignificant. The recognition of the extent to which our commercial prosperity, if not our existence, as a British dominion depends upon the efficiency of the navy is now becoming more general. The amount contributed by New Zealand is now £100,000 annually, but in addition the contribution of a first class battleship is in progress, and it is possible that more complete realisation of our dependence may yet be grasped, so that our contribution may in the future be some larger fractional measure of the commercial benefits that we derive from the supremacy of the British navy.

Since 1903 a Preferential tariff in the form of a surtax on certain classes of goods that are not imported from any British dominion has been in operation. This has greatly checked the rapid

increase in value that these classes of goods showed before the tax was imposed. The value of such goods imported from the United States is no greater than in 1900, and those from Germany in 1909 had lower value than in 1903. Of the total value of imports 5 per cent. are subject to Preferential Tariff.

Chapter X.—POPULATION

The extreme variety of the surface of the land and of climatic conditions has great effect on the distribution of the inhabitants of New Zealand. Whereas the fertility of the soil and the favourable nature of the climate in the more fortunate localities allows of the support of a moderately dense population, there are, on the other hand, extensive mountainous regions where soil is practically absent, or rainfall excessive, that are quite uninhabited; and some of these are even unexplored. It follows that, in spite of the unequalled suitability for occupation and settlement of much of the country, the average **density** of the population is not great. At the last census, 1911, the average of European inhabitants per square mile was 9.62. Of the Australian States, Victoria has a density of population of 14, New South Wales 5 per square mile, Western Australia 1 in 5 square miles, and Tasmania, which most nearly approaches New Zealand in climate and physiographical characters, has an average of 7 persons per square mile. All of these are, of course, small when compared with European countries, for England has a population density of 606, and Belgium

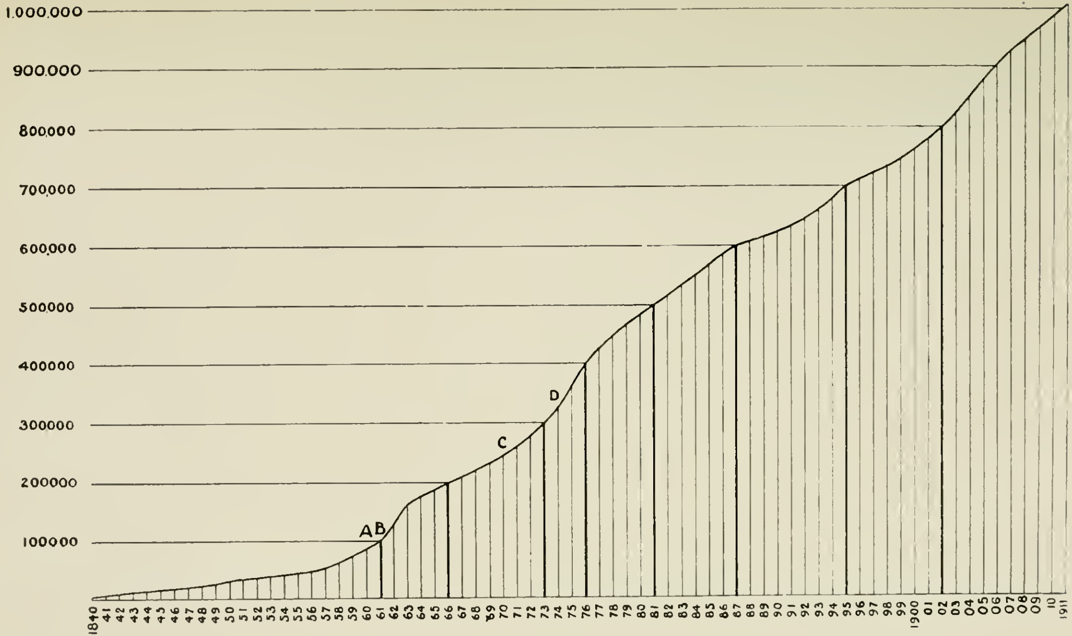
593. It is certain that, for the reasons given above, New Zealand will never support a very dense average population, but it is as certain that a considerable increase in density will take place. Much land, especially in the North Island that is eminently suited for close settlement, is still occupied by virgin forest, and, even in the South Island, some land, now covered by dense bush, will be ultimately cleared and inhabited.

The **increase in population** in the past has, for the most part, been gradual but very regular. The returns of no single year are lower than those of the preceding year. This is, perhaps, more striking when the main cause of the increase of population in the early years is considered. The discovery of the alluvial gold deposits and the exceedingly remunerative returns obtained from them attracted a large influx. In the one year, 1862-1863, the population increased by 39,000; and in the one year, 1873-1874, by 46,000. The former increase occurred two years after the gold production had suddenly jumped from 4,000 to 194,000 oz., and when it had actually reached 500,000 oz. The latter was three years after the high yield for one year of 730,000 oz. This increase of population must, however, be chiefly ascribed to the Public Works Policy and the **state-aided immigration** of this time. As shown in the diagram on page 369, there is a very close relation between the increase of the Public Debt and the increase of the population. Although attracted chiefly by the returns from alluvial deposits, which are always soon exhausted in their richer portions, the miners remained in the Dominion, and either adopted other

occupations, or worked other deposits, from which less striking but still important returns were obtained. The diagram opposite shows how suddenly population increased during the height of the gold fever, and how steadily it has advanced at other times. The increase per annum of late years (about 25,000) has been chiefly due to the **excess of births over deaths.** This excess is about 15,000 each year. The birth-rate is at present 25.85 per thousand of the population. This rate is less than the birth-rate of the Australian States, except South Australia and Victoria. It is slightly less than the birth-rate of England, which in 1907, was 26 per 1000. The natural increase of population in New Zealand is, therefore comparatively small.

Origin of the people.—The larger number (606,000) of the present inhabitants of New Zealand were born in the Dominion. Of the remainder, 209,000 are natives of the British Isles, and of these rather more than half were born in England. Of the total population at the census, 1906, 97.5 per cent. were natives of British possessions. Of the small percentage of natives of foreign countries, 4000 are Germans and 2,600 are Chinese. The number of foreigners is at present decreasing, apparently at the rate of 400 per annum.

The **Maoris** numbered 47,800 at the census in 1906. This is a slight increase on the record of the previous census; there seems little doubt that their number has decreased since the land was first occupied by Europeans, and the decrease in the early years of the century was very rapid, chiefly owing to the destruction that the change to European weapons caused in



Curve of population increase in New Zealand. A.—Gold production, 4,000 oz. B—Gold production, 194,000 oz. C.—Gold production, 730,000 oz. D.—Public Works and State aided immigration.

In five years after 1873, where the curve is steep, the public debt increased by £12,000,000, and in five years after 1903 by £11,500,000. In five years after 1899, where it is flattest, by £1,200,000.

the inter-tribal wars. The majority of the Maoris live in the North Island. The last census returns gave the North Island natives as 45,000, and the South Island as 2,200. A few Maoris live in Stewart Island, and about 200 in the Chatham Islands. In the latter there are also some 31 Morioris living. This is a remnant of an interesting Polynesian race that numbered some thousands when the islands were discovered. They were nearly exterminated by Maoris from the west coast of the North Island, who migrated to the Chathams in 1832. In the Cook and other islands lately annexed to New Zealand, there are 12,000 inhabitants. All but about 200 of these are of Polynesian descent. They are closely related to the Maoris, and speak a dialect very similar to the Maori language.

The **total population** of New Zealand in 1911 was thus:—

Persons of European descent and natives of other continents ..	1,007,811	(1911)
Maori population	47,732	(1906)
Cook and other islands	12,340	(1906)
Total	1,067,883	
In 1906	1,020,713	

This total is less than that of New South Wales and Victoria, both of which have well over 1,000,000 inhabitants, but it is greater than that of any of the other Australian States.

In the early days of colonisation, the **North Island** had more numerous European inhabitants than the South, but, as the pastoral regions of the South Island became occupied, and its goldfields were

developed, its population increased rapidly, and soon became more numerous than that of the North. The occupation of the North Island was retarded by Maori wars, and by the nature of the vegetation that covered it, for time was required to fell the forest and render the land fit for pasture and agriculture. The steady progress of recent years has extended settlement, and year by year the ever-yielding line of primæval bush is pushed further back, and waste lands are gradually changed into smiling farms. At the present time the North Island has a population of 563,862 Europeans, of whom 255,000 are males; and the South Island 443,442, of whom 215,000 are males. The slightly higher percentage of males in the North Island is, to some extent, an indication of the more rapid extension of settlement in that part of the dominion, for it is generally the case that the outsettlers, who carve homes out of the bush, are young unmarried men who have come from the South Island and elsewhere, as well as from the older settled districts of the North Island. In the North Island the distribution of the population is fairly even, though the upper part of the Wanganui coastal plain and the great volcanic plateau is practically devoid of European inhabitants. The former area will, however, probably support a fairly numerous population in the future. This distribution is determined partly by the physiographical nature of the surface, the character of the soil, the nature of the original covering of vegetation, and by the relative accessibility of the land, as well as by the relative friendliness of the original native tribes. The com-

paratively rough surface, occasional areas of poor clay land, the heavy forest, the disinclination of the native tribes to part with their land, and absence of land communication, have retarded the settlement of the north Auckland peninsula, which, though the earliest part of the Colony to be settled, still supports but a scanty European population. On the other hand, the level nature of the Hawke's Bay plain, its covering of grass and fern, its rich soil, the ease of communication, and slight opposition from the native owners, have enabled the settlement of that area to be rapid and complete. The slow settlement of the Wanganui coastal plain must be ascribed to the difficulty of access, in all but the coastal portions, its heavy bush covering, and the unwillingness of the natives to sell land to the Government. The barren pumice soil of the volcanic plateau renders its surface quite unsuitable for industrial occupation. The rugged nature of the mountain range from Wellington to East Cape, and the heavy bush that clothes its sides, have hitherto effectually prevented settlement throughout its extent. In the **South Island** the population is densest on the Canterbury Plains. The east coast of Otago and the valleys of the Mataura and other rivers in Southland are well populated. The plains through which the lower courses of the Wairau, Waimea, and Motueka flow are the other most populous areas. The eastern ranges of the chain of the Southern Alps, and the Otago mountains, as far west as the lakes, are grassed and possess rich valleys, and are thus capable of supporting a considerable number depending upon pastoral industries. The population would, however, be much

greater were it not for the legions of rabbits that have overspread this country, and cannot be exterminated or controlled by the small number of inhabitants that the rather poor pastures can support.

The western flanks of the mountain chain are thickly covered with bush. The rainfall is so heavy that the usual method of burning to clear the land cannot be resorted to, and the usually poor nature of the soil prevents any numerically important pastoral population from settling here. Nature has to some extent compensated for this by endowing the area with mineral deposits. A population, somewhat erratic in its distribution, is supported by the mining industry that is dependent upon these deposits. Some portion of the western slopes is still unexplored, and much is uninhabited.

The population of New Zealand is less concentrated in the **towns** than is that of the larger Australian States. Auckland, Wellington, Christchurch, and Dunedin, between them contain less than one-third of the total population. In Victoria and New South Wales, Melbourne and Sydney respectively contain more than one-third of the population of the State. Of the four chief towns in New Zealand with their suburbs, Auckland, the largest, has 102,676 inhabitants, and Dunedin, the smallest, has 64,237. The latest returns show that, in relation to its population, Wellington is increasing more rapidly than the other towns, the increase being 15,000 in ten years, but the growth of Auckland is nearly as rapid. Of the provincial districts, Auckland and Wellington are progressing far more rapidly than the others, the

increase in five years in the former being rather more, and in the latter rather less than thirty-five thousand.

Future development.—There is every likelihood of this relative rate of increase in population being continued. In Otago and Canterbury and in the South Island generally, nearly all the land suitable for settlement is already occupied. In the North Island, there are large areas of bush land that will in the future support a moderate population. Any increase in population due to such a development will be slow, for much capital and labour have to be expended in clearing the bush, and making the land suitable for pasture and capital. Nor is there at present any sign of rapid increase in industries already established, nor of the establishment of new industries, unless it be that future developments of electrical power will take the place of the steam plants now so widely used. Then it may well happen that New Zealand, abundantly supplied with water power that can be easily and economically used for generating electricity, may become a manufacturing country, and some of the districts at present unoccupied or desert may be hives of industry. Her geographical situation would enable her with such cheap power to supply Australia and perhaps some of South America with the products of industries thus maintained.

Immigration has not had any very great influence in increasing the population of New Zealand. During the interval, 1871-81, part of the passage money of immigrants was paid by the Government,

and a grant of 40 acres of bush land was also given to them. Many of the immigrants who were thus induced to come to New Zealand were penniless; some of them did not wish to take up land. Many hardships were suffered by them, and the rapid increase of population was not accompanied by as rapid an increase in production, as evidenced by the value of exports, which advanced at a much slower rate than the population. At the present time selected immigrants are assisted by a payment that reduces their passage money to New Zealand from England to £10.

Chapter XI.—EDUCATION AND RELIGION.

A small proportion of the population of New Zealand is illiterate. At the last census the returns showed that eighty-five per cent. could read and write. The percentage is highest in those persons between fifteen and twenty years of age. Ninety-nine per cent. of these can read and write. It is the lowest in persons over eighty years of age, for only eighty-six per cent. of them can read and write.

There is a compulsory system of free primary education. All children must attend school or be otherwise instructed while they are between 7 and 14 years of age. At the end of this period it is expected that they will be able to read and write and have an elementary knowledge of arithmetic and other essential subjects. The average attendance throughout the primary schools of the colony is 85

per cent. of the number on the roll. Manual and technical instruction is provided as far as possible, and the boys are instructed in military drill.

The Education Boards of each district offer scholarships that enable the most promising of the primary school pupils every year to attend secondary schools. The number given each year is 177. In addition there are National Scholarships with the same object. The Government also provides free education at secondary schools or district high schools for all those pupils of the State schools who gain a proficiency certificate on passing the sixth standard.

At several of the primary schools provision is made for teaching to a higher standard than that required for primary education. They are then called District High Schools.

This compulsory free education is entirely **secular,** but the adherents of the Roman Catholic religion have established primary schools where religious instruction is provided. Such schools may be subject to ordinary inspection by the Education Board inspectors. There are also several private schools which are attended by about 5,500 pupils. Native schools exist in many of the Maori villages, and about 6,900 native children are being educated. The Government has established several industrial schools to which children guilty of various offences are sent. There are also some private industrial schools which receive Government support.

Secondary education is provided at several schools situated for the most part in the larger centres of population. Nearly all of these are undenominational. They are supported, partly by the rents

derived from endowments, partly by the fees paid by the scholars.

The New Zealand **University** was established in 1870. It is an examining body only, and employs men of eminence in various branches of science and literature in England to examine students that present themselves for degrees in Arts, Law, Science and Medicine. There are four teaching University Colleges, at which students are prepared to sit for examinations for the degrees of the New Zealand University. The teaching colleges are established at the four chief centres: Otago University at Dunedin, and Canterbury College at Christchurch, are supported chiefly by the old provincial endowments, but Auckland College and Victoria College at Wellington have been more recently established and depend almost entirely on Government grants. At present 1,819 undergraduates are attending lectures, and degrees have been conferred on 1,421 graduates.

Attempts have recently been made to promote **technical education**. In many of the primary schools, classes have been established in various branches of technical work. In addition, technical schools exist in most of the larger centres. At these schools instruction is given in a great variety of technical subjects, such as various branches of art, joinery, carpentry, cooking, dressmaking, and wool sorting. They are attended by 1,800 free students. There are also mining schools at the Thames, Karangahake, Waihi, Reefton and Coromandel.

There are technical schools for University education at Christchurch and Dunedin. At the former,

students are prepared in Engineering and Agriculture for the degrees in these subjects for which the New Zealand University provides examination. At Dunedin there are Schools of Medicine, Dentistry, and Mining engineering, and large numbers of specially trained graduates have been educated in them. At Auckland and at Christchurch there is a University School of Commerce.

The University gives 17 scholarships annually to pupils of secondary schools, and the Government gives 20 Senior National Scholarships for candidates at the same examinations. These scholarships are of sufficient value to enable the holders to have free education for three years at one of the University Colleges.

The **Cost of education** in New Zealand is great when the small population is considered. The Education Boards receive from the "Public Funds" £812,000 annually for primary and some of the secondary education. Other sources of income raise this amount to £887,000.

For secondary education the Government grants £76,000, but other receipts raise the total income of these schools to £100,000. The industrial schools cost £39,000; technical education, irrespective of University Schools, £59,000; native schools, £32,000. University education costs £53,000, of which only £26,000 is a Government grant. The total expenditure under these heads amounts to £1,096,000. This total sum is more than £1 per head of the total population.

In addition to the mere teaching, the education of the people is maintained by public **libraries** and the dissemination of newspapers.

There are 437 public libraries subsidised by the Government; they are distributed uniformly throughout both islands.

Two hundred and thirty-six registered **newspapers** are published in New Zealand. Sixty-six of these are daily papers. Several of the weekly issues, of which there are sixty-eight, are well illustrated. These papers maintain a uniformly high standard and are themselves an index of the educated taste of the population.

Religion.—Nearly all the inhabitants of New Zealand are professed adherents of some creed of the Christian religion. Almost 700,000 of these belong to some form of the Protestant faith. The Church of England, which is governed by six Bishops, in the Sees of Auckland, Waiapu, Wellington, Nelson, Christchurch, and Dunedin, has the largest number of adherents, 41 per cent. of the whole population. The Presbyterians are almost half as numerous, 23 per cent.; and the Methodists and Baptists are next in order. The Roman Catholics number 127,000; there are four Sees, Auckland, Wellington, Christchurch, Dunedin.

Chapter XII.—GOVERNMENT.

As previously stated, the form of government is similar to that of the United Kingdom and of her other self-governing colonies. A **Governor**, who is appointed by the Crown, holds office for five years. For the last twenty years a peer of the realm has been appointed. At present, the Governor is Lord Islington.

There are two deliberative bodies, called the **Legislative Council** and the House of Representatives. The former consists of thirty-nine Councillors, but no definite limit is assigned for their number, though there must be more than ten. Before 1891, appointments were made for life, but since then seven years has been the term of office. The Council elects its own Speaker every five years. Councillors are appointed by the Governor. A Councillor must be as much as 21 years of age, and must be a subject of His Majesty. Contractors for the public service and civil servants are ineligible.

The **House of Representatives** consists of eighty members; seventy-six of these are Europeans, and four are Maoris. Forty-three European members come from the north island and thirty-three from the south island. Three Maori members represent the North and one the South Island. The constituencies are divided on a population basis, but natural geographical divisions are adhered to as far as possible in fixing their boundaries. The franchise is extended to every adult person in the dominion, and every male over twenty-one years of age, who is not a contractor for the public service and is not a civil servant, is eligible for election. Elections are held every three years. The House elects its own Speaker, and he holds office until the next general elections. All members of both Houses are paid. Those of the Legislative Council receive £200, and those of the House of Representatives £300 per annum.

The **Executive Council** consists of ten members. His Excellency the Governor is an ex-officio member.

The Council consists of representative men of the political party that was returned with a majority at the last general election.

When a Government is defeated, the Governor, on receipt of its resignation, summons the most prominent member of the opposing party. If he undertakes the formation of a ministry, he chooses representative men of the party to form an Executive Council. They hold office until resignation or defeat.

The present **Premier** is the Right Hon. Sir Joseph Ward, Bart., P.C., K.C.M.G., who has held office for five years. Eight members of his Executive Council hold portfolios of various Government departments. and constitute the Cabinet.

Any legislative measure has to receive the votes of the majority of members present in the House at the time it is considered. It must pass both Houses, and receive the assent of the Governor before it becomes law.

The universal franchise has enabled the people to elect representatives pledged to advanced and even socialistic **legislation**, the effect of which has been to increase the material comfort of those who perform manual labour, though it is often stated that industrial enterprise is rather discouraged. Amongst the more important products of this legislation is the Industrial Conciliation and Arbitration Act, which compels the reference of industrial disputes between employers and employed to specially constituted Councils of Conciliation or to the Court of Arbitration. Both parties are legally bound to adhere to the awards of the Court. Another Act

makes a weekly half-holiday compulsory in all trades. The length of a day's labour is legally fixed at eight hours, and employers who disregard this are liable to heavy penalties. The hours at which shops must close has also been fixed by law.

In all trades, associations of employees have been formed. These are called unions. Those that are registered are recognised legally, and their officers assist the Government Inspector in bringing before the Arbitration Court instances in which breaches of awards of the Court have been made, and of hardships suffered, or improvements required, by the employees in the trades that they represent.

The legislation in regard to **land** has also shown some remarkable features within recent years. No single settler is allowed to acquire more than a limited amount of Crown land. The actual amount varies from 640 acres of the best agricultural lands to the unspecified area of poor pastoral country that will support 20,000 sheep or 4,000 cattle. The Government has for the last ten years borrowed money for advancing loans at low rates of interest to settlers. These loans have given farmers an opportunity of improving their land to a greater extent than would have been possible if the money had been borrowed at higher rates. The amount of the advance is not allowed to exceed £3,000 in any case, and it may not be greater than three-fifths of the value of the security on which it is advanced.

Up to the end of 1909, £5,662,000 had been granted as advances to settlers. Advances are now made to workers in towns upon leasehold or free-

hold properties. The sum of £818,000 had been advanced up to the end of 1909.

Another Act allows the Government to acquire land compulsorily for settlement. This was passed to break up the large estates that were acquired in the early days of settlement. It is maintained that such large estates are managed for the owner by a few shepherds and stockmen, when in some cases they are capable of supporting a large number of small farmers, who work the land to greater advantage. The estates that are purchased are let out in small areas for a rental equal to five per cent. of the money spent on their purchase. Up to 1909 as much as 1,238,000 acres of land had been purchased for a sum of £5,400,000. More than a third of the land so acquired is in the Canterbury and Auckland Provinces, though some estates in all the other provinces have been bought.

The **local government** of New Zealand is in the hands of county councils, borough councils, town boards, road boards, and harbour boards. In addition to these, some special boards exist for particular purposes in the districts controlled for more general purposes by one or more of these boards. Such are education boards, school committees, river boards, drainage boards, water supply boards, and land drainage boards.

Mayors are elected annually to preside over the borough councils and town boards. The members of these boards are elected by all those who possess residential qualifications within the district over which the board exercises control. The functions of

the more general boards are to establish by-laws for the regulation of all the local requirements of the district, and to attend to all the details of local government and administration. The names of the more special boards indicate their functions.

The funds required by the local bodies for the administration of their districts are obtained by general rates on the area over which they exercise control, and by the issue of licenses. Loans have also been raised by many of them to meet the demand for rapid development. The general government has of late years been lending money in sums of £2,000 or less to the local bodies at rates of interest varying from four to five per cent., according to the length of the period for which the money is borrowed. The sum of £1,840,000 has been loaned in this way.

The population of the country takes great interest in politics as is shown by the fact that 99.5 per cent. of the adults of both sexes are registered electors. The proportion of these that vote is also high. In 1908, as many as 81 of the males and 78 per cent. of the females registered votes.

At the general elections a poll is also taken on the subject of the liquor traffic. This is a **local option poll**, and each electorate can, by a majority of three-fifths of the total votes, prevent the issue of licenses to sell liquor in an electorate where they were previously issued, or establish a licensed traffic in an electorate where there was previously none. An elector can also vote for continuance or reduction of licenses, and an absolute majority of the total votes recorded will carry either of these proposals. If none

of these is carried, the licenses remain undisturbed. At the elections of 1908, out of the sixty-eight licensing districts, fifteen were in favour of continuance of existing licenses, thirty-four carried no proposal, seven were in favour of reduction, and six for no license. In six no license districts there was a decision against the restoration of licenses. An Act has now been passed which allows of a bare majority of electors carrying dominion no license.

Chapter XIII.—TAXATION AND NATIONAL DEBT.

The necessity for railways, roads and bridges to enable settlers to bring their produce to market and general expenses incurred in developing the country have caused the expenditure of large sums of borrowed money. Although most of this has been obtained at low rates of interest, the annual charges amount to a large sum. The payment of these have to be provided for out of money raised by taxation.

Direct taxation of land and income provides an important fraction of the sum required, and most of the remainder is raised by **indirect** taxation through the customs duties.

All **land** at present is subject to a tax of a penny in the pound, and this brings in a revenue of £417,000 per annum. Improvements are not reckoned in the value of the land, and reductions are allowed for mortgages, which are separately taxed three farthings in the pound.

In addition there is a graduated land tax on all properties that have an unimproved value of £5,000 or more. The lowest imposition of this tax is 1/16th of a penny in the pound, and it rises to 4⅛d. when the value of the estate is £200,000 or more. This graduated tax yields £220,000 of revenue.

The **income-tax** is imposed on all incomes greater than £300 per annum; its amount is deducted from all taxable incomes. Its amount is 6d. in the pound for all incomes less than £700 per annum. The tax is graduated and reaches 1/2 in the £ on the taxable balance of all incomes over £2,300. The income tax yields £321,000 per annum.

The indirect taxation is applied to nearly all articles that are imported into the dominion. The **customs** tariff has been framed primarily with the object of raising the revenue. The incidence of the taxation has been so arranged as to encourage the manufacture of such articles as can be satisfactorily made from local products, and also with the object of extracting the money from those that require luxuries by remitting the taxes on ordinary articles of food. Thus clothing that can be made in the dominion is subject to a tax of 40 per cent., and boots 22½ per cent. Rice and salt are free, and tea has a low duty. Tobacco is taxed 3s. 6d. per pound, and spirits 16s. per gallon. Machinery is taxed but little and for several industries it is admitted free.

In addition to the taxation imposed by the General Government, the various **local bodies** have power to strike rates on the property owned in the districts over which their control is exercised. The amount and value of the rate differs in the various districts.

The limit of threepence in the pound on the capital value of rateable property has been imposed by law in every case. Local bodies are now allowed to substitute a rate on the unimproved value of land in the district in place of the general rate. This method has been adopted by 120 local bodies.

The total amount raised by local bodies by taxation in 1909 was £1,710,000, equal to £1 14s. per head of the population. In addition to this the local bodies received £225,000 from the Government, and other sources of revenue raised their total receipts to £3,619,000. The greater part of this money was expended on public works in the districts controlled by them.

The total amount of revenue raised by the customs duties is £2,786,000 and this added to the total of £1,115,000 raised by direct taxation and to certain other taxes produces a **total of revenue** of £4,245,000 raised by taxation. This amount is equivalent to £4 7s. per head of the population.

An **Excise duty** of 3d. per gallon on beer produces a revenue of £118,000, and fees for registration and various miscellaneous taxes produce a total of £427,0000.

In addition to the amount raised by taxes the revenue is largely increased by the **railway receipts** which amounted to £3,485,000 in 1910-11, and by the post and telegraph receipts of £1,846,000. The total revenue is thus raised to £10,300,000.

The largest item in the **dominion expenditure** is £2,450,000 for interest on the loans raised. The working of the railways cost £2,270.000; the post and telegraph office £911,000; education £925,000; defence

£213,000; old age pensions £366,000; judicial and legal £407,000. The maintenance of hospitals, asylums, and the various government departments and legislative bodies have cost sums that raised the total colonial expenditure in 1910-11 to £9,343,000.

For some years past the **revenue** has exceeded the expenditure, and the excess has been transferred to the Public Works Fund. Thus a commencement has been made towards a self-reliant policy, for the necessary roads, bridges, and railways are constructed partly out of revenue.

The figures issued for 1911 show a larger revenue and a larger expenditure than those of any previous year.

The following are the principal items:—

Revenue.		Expenditure.	
Ordinary land tax / Graduated ,, ,,	£629,000	Interest on loans	£2,458,000
		Railways	£2,270,000
Customs	£3,028,000	Education ...	£924,000
Railways ...	£3,484,000	Post and telegraph	£911,000
Post and telegraph	£1,848,000	Judicial and legal	£370,000
Beer duty ...	£118,000	Old age pension ...	£366,000
Income tax ...	£407,000	Defence	£212,000
Other sources ...	£783,000	Other expenses ...	£1,822,000
Total	£10,297,000		£9,333,000

From the surplus £500,000 was transferred to the Public Works Fund.

Public Debt.

The fact that most of this money has been spent developing the resources of the dominion amounted on March 31st, 1911, to £81,075,000.

The fact that the most of this money has been spent in making railways and establishing telegraph services

and in various other matters of a directly remunerative nature, places this debt on a different plane from those of the European countries where most of the borrowed money of the public debt has been absorbed in the expenses of wars in which the countries have been engaged. In other words New Zealand has large securities in the substantial public works throughout the country in addition to that afforded by the ordinary revenue.

The average rate of interest payable on this debt is £3 13s. 3d. per cent. an amount that shows a decrease of 17s. since 1891.

The sums that constitute the public debt have been borrowed from time to time at various rates of interest, which are determined partly by the general price of money in London, partly by the credit of the dominion for the time being. The loans at present outstanding have been borrowed at rates varying between 6 and 3 per cent., though all but £400,000 bears interest from 3 to 4 per cent. From time to time some of the loans fall due, and can sometimes be renewed at a lower rate of interest. Such **conversion operations** have of late years lowered the average rate of interest paid on the public debt. **Sinking funds** of £3,112,000 have accumulated, so the net public debt is £77,775,000 and this amounts to £77 15s. 8d. per head of the population and the annual interest on this sum is £2 16s. per head.

The New Zealand public debt is greater than that of any Australian state, except New South Wales, and the debt per head of the population is greater than that of all of the Australian states except

Queensland. The average for the whole Commonwealth is £57 16s 6d.

The money has been expended for the most part upon objects that bring in directly or indirectly some return of revenue. The most important for 1910 were:—

Railways	£24,453,000
Roads and bridges	6,871,000
Public buildings	5,240,000
Land purchases	2,280,000
Telegraphs	1,432,000
Purchase of land for settlement	6,270,000
Advances to settlers ..	5,624,000
Loans to local bodies ..	3,837,000
Total	£56,007,000

This total represents 74.7 per cent. of the money that had been borrowed up to that year. £12,102,000 is in no sense remunerative. It has been expended in raising the loans, in paying deficiencies in revenue and various other items.

Besides the public debt a large sum of money has been borrowed by **local bodies.** The total amount is £13,303,000 and the annual interest charges on this amount are £616,000. Nearly £7,785,000 of this has been raised within the dominion. The money has been borrowed at an average of about 4.63 per cent. In addition £1,839,000 has been lent by the General Government. This is done because the security possessed by the General Government is better than that possessed by the local bodies, and it can therefore borrow money at lower rates of interest.

CHAPTER XIV.—RELATIONS WITH AUSTRALIA AND THE EMPIRE.

When the federation of the Australian Colonies was accomplished and the island continent became a Commonwealth, New Zealand held aloof. It was thought that the probable commercial benefits that would be derived would be over-balanced by the inconvenience that government from a centre 1500 miles distant would entail. At the same time the conditions of all kinds are rather different from those of Australia, and it was thought that legislation suited to the conditions and circumstances of Australia might often be unsatisfactory if applied to New Zealand. The isolated position of New Zealand might have resulted in injustice being done her when matters concerning the welfare of the whole Commonwealth were considered. There was also a general feeling against a surrender of any moiety of that independence in regard to all matters, except Imperial questions, that the country possesses.

The trade between New Zealand and Australia, which annually amounts to about £5,000,000 in value, shows that the two countries have considerable commercial interest in their mutual existence. This is most pronounced in New Zealand, for Australia takes a seventh part of our total exports. More important, however, is a community of sentiment, for both countries recognise that they have common

social interests in the Southern Seas, and they view with grave concern any attempts made by foreign powers to establish colonies or stations in the South Pacific. They recognise, too, that their interests are strictly concerned in the maintenance of the wide-spread British Empire in its integrity, and the population is intensely patriotic to the Empire. New Zealand occupies such an antipodal position with respect to England that it may be described as the outpost of the British Empire. Situated at such a distance from the large and more important possessions of the European powers, it would probably be secure from any attack by foreign naval squadrons. Naval movements are so entirely dependent upon coal supplies that no foreign power could despatch hostile vessels to the New Zealand coast unless there were a certainty of capturing one of the ports and securing a coal supply without any loss of time, and without damage, unless the British fleet had been crippled. The defences of the New Zealand ports and the forces of local volunteers are probably strong enough to prevent this. As soon as the compulsory service scheme is in operation the landing of a hostile force will be far more precarious.

The great preponderance of naval strength possessed by Britain in the Southern Seas is the true guarantee of security. No other power possesses naval stations in the South Pacific where repairs could be effected, or where a war vessel could retire for coaling or victualling, without being in imminent danger of attack by the British navy.

From an Imperial and naval point of view, the position of this outpost has advantages as well as

disadvantages. It affords coaling stations, and at Auckland a naval base where docking and repairs to war vessels can be effected. On the other hand the inclusion of New Zealand in the British Empire considerably increases the ocean area that has to be efficiently patrolled and the length of coast line that has to be protected. It is generally believed that such an outpost as New Zealand would, in the event of naval war, suffer far more severely from the interruption of its commerce than from any direct attack. If this view is correct, it follows that the maintenance of the power and efficiency of the British fleet, which alone can protect this commerce from injury, is of greater local importance than the establishment of defence works and forces. Were New Zealand in the hands of a foreign power, it would seriously menace Australian waters and the Australian coast line, and the strategic strength of the British position in the Southern Pacific would be greatly lessened.

Moeraki Boulders.

Chapter XV.—THE MAORIS OF NEW ZEALAND.

(A. HAMILTON.)

The nineteenth century saw the enclosure of the Islands of New Zealand within the pale of European civilization. The grandchildren of the early settlers, the travellers and the tourists of to-day can see but little trace of the former inhabitants of this country. Bent on business or pleasure, they pass from north to south or east and west through scenes and districts which differ but little from many English counties. The names of many of the places are strange, and are tacitly recognised as Maori, but to very few do they convey any historical association or suggest any reason for the name given to the locality. The natives themselves have become such a small remnant that, in the South Island, they must be specially sought for to be seen at all.

There are signs that a new generation of natives is about to undertake the task of elevating the surviving remnants of the race to a higher plane of civilisation, hoping that the application of modern scientific training to their daily life may be the means of staying the gradual extinction which seemed destined to be the ultimate fate of the once great Maori nation; and I think it will conduce to this very desirable end, if there can be established a better knowledge of what was the stage of civilisation on which the Maori people lived in the height

of their prosperity as a free nation, a nation which had for its country one of the gems of the Pacific, not a sun-scorched coral isle, but a country which, by its physical features and climatic conditions, contributed not a little to the perfecting of the personal qualities of the individual both in mind and body.

There is no doubt that there are many who desire to know something of the history of New Zealand, especially before the discovery of the islands by the early voyagers, but when an endeavour is made to obtain information, it will be found more easy to find out works giving the details of the daily life of the Normans in England than to get a glimpse of the daily life of the old New Zealanders.

The literature of the subject is widely scattered and contained in books which are sometimes rare and costly, and often information is partial and incomplete. The information relating to customs and manners is also, in many cases, untrustworthy, being largely influenced by the personal opinions of the observers, particularly if the subject be one of a sacred or religious character, and more often by misunderstandings arising from an imperfect acquaintance with the language and mode of thought of the natives.

From the earliest times to the present, the better class of Maori have regarded the pakeha as a person quite without manners in the ordinary actions of daily life. They themselves were particularly careful not to cause offence by an incautious word or look, nor did they find fault with any doings or sayings of visitors, of their own race, even when they might have done so with justice, and their social

intercourse was subject to much ceremonial observance.

Origin.—The growth of the Maori dominion in these islands seems to have been spread over a period of about 500 years. The difficulty of arriving at any approximate date for the advent of the Maoris is enhanced by the total absence of any form of record written or graven. Close enquiry and careful comparison of the genealogies given as evidence in the Land Courts has enabled experts to affirm that the colonisation of New Zealand by the Maoris took place about 500 years ago.

It is admitted by all that several migrations, or hekes, were made about that date, and that most of the canoes and the migrating chiefs claim to have come from Hawaiki. This Hawaiki is the name of the island most generally referred to by New Zealanders as the place from which their ancestors came, but from Maori legends it is clear that this ancient name was applied to more than one place or home of the people. Other names are given for their fatherland such as Tawhiti, Wawau, Mataora, Raro, and Nukuroa. Other branches of the Maori race in the Pacific Islands name Atia as their original home. The Rarotongans speak of Atia as Varinga-nui, from which some scholars deduce a former knowledge of rice in a land where it grew in plenty as a food-plant, possibly India.

There is a general agreement in all the traditions of the Polynesian race that they entered the South Pacific from the West, and much has been written by philologists in support of this idea, but although the last ten years have seen very important additions to

our knowledge of the wanderings of the Polynesians, I think further study is requisite before the various records can be interpreted and arranged in proper sequence.

Native traditions have made it clear that the wide expanse of sea, surrounding the various groups of islands in the Pacific, formed no bar to voyagers at suitable seasons of the year guiding their course in various directions by the stars, the currents, and in some instances by primitive charts made of thin twigs tied together in certain forms with the courses marked by strings and the islands by small pieces of wood tied on.

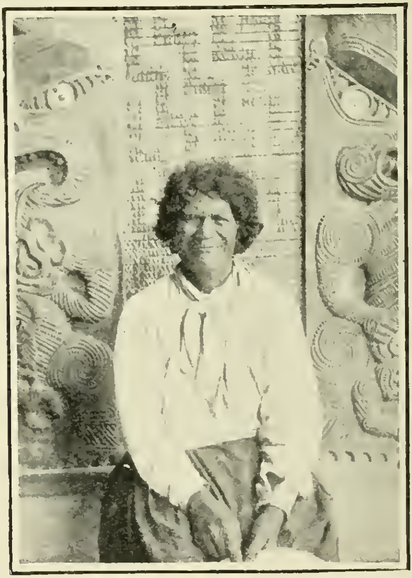
Mr. Percy Smith, in his book on Hawaiki, gives, from two traditions preserved in Rarotonga, an account of the commencement of the great voyages of the Rarotongans and Maoris about 48 generations ago, or about the year 650, when a chief named Ui-te-rangiora determined to emigrate to other parts, in consequence of sacrilege committed by some of his people in connection with the building of a great canoe.

This was the commencement of the voyages of the Rarotongans and Maoris, during the continuance of which they—in the words of the history—"visited every place on earth," and "they became a people accomplished in navigating vessels."

The list given in the tradition shows that these voyages extended from Hawaii to New Zealand, some 4,000 miles, and probably from the New Hebrides to Easter Island, about 5,000 miles.

The great heke or migration to New Zealand is said to have taken place about four hundred years

ago, and appears to have consisted of a small fleet of canoes carrying a number of Polynesians, their wives and slaves, and stores of their ordinary food for consumption on the long voyage. Their greatest anxiety must have been about water, as only a very small supply could have been taken in calabashes.



A Maori woman seated on the verandah of a large carved house near the East Cape.

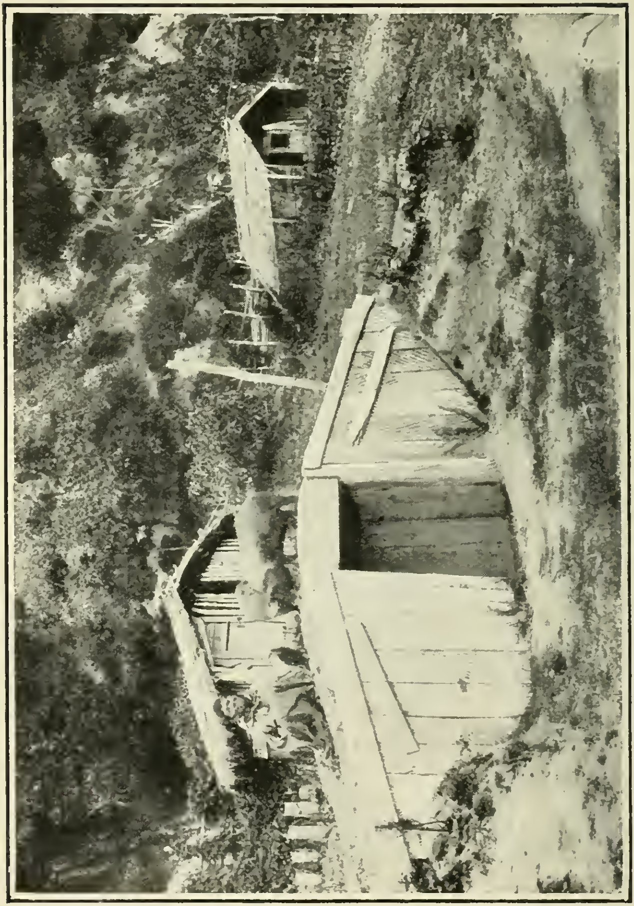
The names of the canoes, which reached the coast of the North Island of New Zealand at various points, have been preserved with circumstantial accounts of the incidents of the arrival.

Aborigines.—There appears to be little doubt that these visitors found inhabitants already in possession of settlements, and there is a possibility that these

early inhabitants were more Melanesian than Polynesian. In any case they seem to have been quickly absorbed by the more vigorous race.

There are some points of great interest to be remembered in the discussion as to the past history of the Maori. These are: first, their ignorance of iron or any metal; secondly, their ignorance of any kind of pottery; thirdly, their ignorance of the bow and arrow; fourthly, their ignorance of smoking or making fermented drinks. Mr. Colenso was of the opinion that five hundred years was far too short a time to permit of the growth of the various local dialects, and the wide divergence of the manners and customs, weapons, ornaments, and art from those of other islands. Also in his long years of travel in the North Island from Cook Strait to Cape Maria Van Diemen, during more than a quarter of a century, by paths long disused, through forests and over mountains and hilly ranges, he was astonished at the signs frequently met with of a very numerous ancient population who once dwelt at places long since desolate and uninhabited; at the number and extent of their hill forts, cut, levelled, escarped, moated, and fenced only with immense labour, considering that their tools were simply of wood or bone, the number and extent of their ancient cultivation, all long since overgrown, and the enormous mounds of river, lake and sea shells, sometimes clearly revealing the slow accretions through years or centuries by the intervening layers of earth or sand and shells.

The same memorials of antiquity can be seen all along the coast of the South Island, and traces of



A storehouse for kumara (rua). Two ordinary whares in the background; old Maori woman and her pigs on the earth-covered roof of the rua.

man in the remotest wilds of the interior. The number of greenstone weapons and ornaments in the North Island is also a proof of the long intercourse with the natives of the Southern Island or the Western Coast.

These remains of old settlements lost and buried under shifting sand hills, or forest trees and bush, are now gradually yielding up relics which may, in time, afford us valuable information as to the olden race. If only the Maori had been a potter, we should have had a chance of deducing the age of settlements from the almost imperishable fragments which in other countries afford a convenient chronology.

Bone and stone implements are much the same in form in this century as five or six centuries ago. It is only in ornaments for personal adornment that striking changes of form seem to occur from time to time.

Distribution.—The Maoris, previous to the coming of Europeans, were most numerous in the North Island, living together according to their relationship, in large fenced villages, near to which was a hill fort defended by wooden palisades, ditches, and banks, exactly similar to prehistoric forts or raths in Ireland, and most of the central and southern countries of Europe. To this fort, or *pa*, they retreated when attacked by their enemies.

Daily Life.—In ordinary life they were strictly ruled by their chiefs, and were industrious, regular and cleanly.

They rose early and had but two meals a day, morning and evening, always in the open air, and

in separate groups according to rank and sex. Each day brought its labour, and, for the support of the community the men went off to their cultivations, or to fish from their canoes, or perhaps, if it were the season to snare birds, into the leafy recesses of the bush, to catch the edible rat on the mountain ridges, or to set baskets and nets for eel in the swamps and creeks. At other times forest fruits, berries, and leaves had to be gathered for sick people, or fern roots dug to be stored away for winter use. Others, expert in the use of tools, would repair or build houses, canoes, fences, earthworks, eel-weirs, or see to the felling and bringing out of trees and split-timber from the forest, or make troughs for the bird-snares, paddles, spears, axe handles, and all kinds of fighting weapons of wood, bone, or stone.

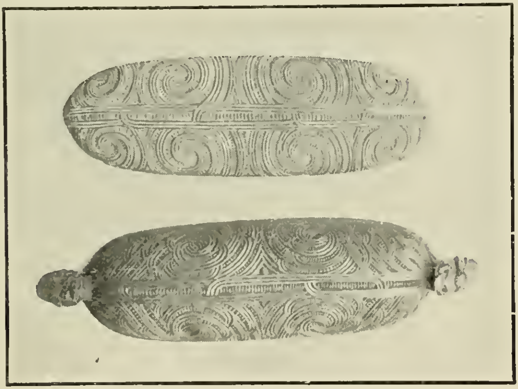
Others, again, would make fishing lines, ropes, and small cord, nets, fish traps, canoe sails, or prepare strips of dog skin for their most valuable cloaks, or in leisure moments carve combs, flutes, rings for tame decoy parrots from bone or greenstone, fish-hooks, pins, and various ornaments.

Sometimes coloured earths, vegetable and animal oils, feather and vegetable dyes had to be procured, so that the warriors and chiefs might adorn themselves. On rare occasions the drying and preserving of heads had to be done by a long and difficult process.

For canoes and houses much carved work had to be prepared, and some of the more elaborate canoe ornaments must have taken years to work out from the solid log. The hollowing out of the log for the

hull of the canoe was effected by the use of fire and the chipping out of the charred portion.

The women, as in most countries, were entrusted with the preparation of food, and the weaving of small baskets of green flax in which the food was served, no baskets in which cooked food had been placed being used twice. They had also to gather shell fish from the banks in the estuaries, to clean the



Carved box for holding feathers for the hair or greenstone ornaments.

seafish brought in by the fishers, to fetch firewood, prepare flax, to plait it, and weave it into clothing and baskets of very many different kinds. Then at certain seasons weeds grew apace in the cultivation and had to be destroyed and fresh gravel fetched from a river bed and placed on the kumara beds. A number of plants in the bush furnished them at different times with small edible berries, the collection of which involved much labour. The Maori was a great consumer of fish, and the shell-fish found on the coastal tidal flats, and in the proper seasons the

cliffs and breeding places of the seabirds afforded young shags and other young seabirds, all much esteemed as food.

For **clothing** or covering they relied almost entirely on that most useful plant the phormium, which was to them almost as useful as the coco-nut palm is to the natives of more tropical regions. Mats of all kinds, from the roughest rain cloak to the silky kaitaka mat, were constructed in the simplest fashion, and besides being ornamental, were lasting, and were well adapted for the use of the wearer in a rapidly changing climate like that of New Zealand. If soaked with rain they were easily thrown aside or dried, and no ill effects followed to the wearer. The adoption of European clothing, which is kept on wet or dry, has assisted the spread of chest diseases to an alarming extent.

Buying or selling for a price was of course quite unknown among the old Maoris, but exchange, or **barter**, in the form of presents, were made of food, clothing, or articles of use, in expectation of a suitable return.

Physically the Maori race take a high place in any comparative view of mankind at large. Their constant exercise in outdoor employment, and a natural process of elimination of the unfit, resulted in a tall, well developed muscular race, inclined to be heavy and somewhat short in the legs from the point of view of a European. The women were of somewhat massive build, but with well shaped hands and feet. Those who are pleasing and well shaped in youth soon become bulky and more attractive from a Maori point of view than from that of a

Carving representing an ancestor fully tattooed.

European. The hair is of a beautiful black colour, and either strongly curled in short waves or long and straight.

Occasionally an older strain of light reddish brown hair is to be found, mainly amongst the Urewera people.

The facial characteristics vary very much in different parts of the country, but the majority have a wide and somewhat flattened nose and in some cases this flatness is assisted by pressure in infancy. The custom of marking the face and some parts of the body with incised lines blackened with soot or other material gave a very striking appearance to the

person so ornamented. As hairs on the face would cover or interfere with the tattoo they were pulled out by the roots by means of a pair of shells used as tweezers.

Constant practice in warlike exercise produced a corresponding skill in the use of weapons and great agility in feats of strength and daring. All writers agree that the Maori in olden time had very few diseases, and if he escaped the perils of war and witchcraft, would probably die of old age.

Very great attention was paid to matters relating to ancestral **rank**, and the distinctions were keenly noted and observed.

First were the two clear divisions of freemen and bondmen or slaves. The freemen were of well-known birth and lineage and the head of the house was the eldest born male (or in some cases the eldest female), and his title was that of *ariki*, a widely used Polynesian word, best interpreted as lord of, or head of, the tribe, with priestly powers. After him in rank came the principal chief of the sub-tribes. The various ranks below this were so complicated by varied relationships that the subject becomes very complex and intricate. Slaves were usually prisoners captured in war, and the old writers state that though not "freemen" they were not illtreated.

Property was either personal or common. That is to say every man had a right to his own, as against everyone else, provided that he was strong enough to keep it. If a man of middle or low rank was lucky in snaring birds or fishes, the spoils were undoubtedly his own, but if his superior chief asked for some, he dared not refuse, even if he would, for the taking

of the birds and fish it was understood would be repaid at a convenient season with interest. It was the same with his house, his tools, his weapons, and his clothes.

To **land** a man acquired a peculiar right in many ways, some of which seem strange and to us trivial, and such rights could be transmitted by him to his descendants. What the land spontaneously provided, was common to everyone, subject to hereditary rights to certain spots providing food of special value, such as fern root or shell-fish.

Owing to the great disturbance of the balance of power, caused by the advent of guns and gunpowder, the claims to various portions of the North Island of New Zealand became much more complicated and involved, and the ancient tribal boundaries became more difficult to define.

In his essay on the New Zealanders written for the Commissioners of the Dunedin Exhibition of 1865, the late Rev. W. Colenso gave a table of the number of natives then belonging to the different tribes, the approximate area of ground occupied by them, and the geographical situation of each tribal area.

The following table shows the names of the Maori tribes of New Zealand arranged geographically from north to south, so far as is possible:—

NAME OF TRIBE.	GENERAL LOCALITY.
Te Au-Pouri	North Cape
Te Rarawa	Awanui
Nga-Puhi...	Bay of Islands, etc.
Ngati-Whatua	Kaipara
Ngati-Te-Ata	Manakau
Ngati-Paoa	
Ngati-Maru	Hauraki Gulf
Ngati-Whanaunga	

NAME OF TRIBE.	GENERAL LOCALITY.
Ngati-Raukawa ...	Thames and Waikato Valley
Waikato ...	Waikato Valley
Ngati-Maniapoto ...	Waipa, etc.
Ngati-Tu-Wharetoa ...	Taupo
Ngati-Te-Rangi ...	Tauranga
Te Arawa... ...	Rotorua, Bay of Plenty
Ngati-Awa ...	Bay of Plenty
Te-Ure-Wera ...	Urewera Country
Whakatohea ...	Opotiki, etc.
Te-Whanau-a-Apanui ...	Bay of Plenty, East
Ngati-Porou ...	East Cape, Southwards
Ngati-Kahungungu ...	Poverty Bay to Wellington
Ngati-Tama ...	Mokau
Te-Ati-Awa ...	Waitara, etc.
Taranaki ...	Cape Egmont
Ngati-Ruanui ...	Patea
Ngati-Rauru ...	Waitotara
Ngati-Hau (or Whanganui) ...	Whanganui
Ngati-Apa ...	Manawatu
Ngati-Toa and Ngati-Raukawa ...	Otaki, etc.
Rangitane ...	South of Otaki
MIDDLE ISLAND.	
Ngati-Toa ...	North of South Island
Ngati-Awa ...	Marlborough
Rangitane ...	
Ngati-Kuia ...	Pelorus Sound
Ngai-Tahu ...	Canterbury, Otago, Southland, Stewart Island
Te Ati-Awa, and a few Morioris ..	Chatham Islands.

The above are the principal tribes, which are divided into very many sub-tribes.

In the olden time the **South Island** of New Zealand was known as Te Wai Pounamu, Mohua, Aopawa, and sometimes as Tumuki, and the particular portion now known as Otago and Southland as Murihiku.

Much as we should like to know the history of the southern part of New Zealand in the olden time, it is certain that we can get only a very incomplete idea of the manners and customs of the people who have passed away and have left the traces of their occupation of the land in the shape of huge accumulations of shells, fish bones, and other relics of their hearths

and homes. One tradition states that a people known as the Ngati-Mamoe were the original *tangata whenua*, or people of the soil. There are still some natives who claim descent from these ancient people, but the majority of the Maoris who held possession of the district south of the Waitaki during the last century were descended from the more war-like men of the north of the Ngai-Tahu tribe, who crossed the Strait and found an easy prey in the peaceful dwellers in the south. If we go back still further, to the very earliest shadowy traditions and the fragments of genealogies that have been preserved, we find the very first people spoken of as inhabiting the South Island are the Kahui Tipua, a tribe of whom many weird tales are told, and who are generally classed as supernatural beings, hence their name—Te Kahui Tipua—the band of ogres. After these fearsome creatures, one of whom had a pack of ten two-headed dogs, came Te Rapuwai, of whom also but little is known, but in whose time it is said that the moa was exterminated, and the fire of Tamatea spread over the land destroying the forests of Otago and Canterbury.

Although the above are generally regarded as semi-mythical traditions, it is probable that they contain elements of truth, and that Te Kahui Tipua and Te Rapuwai were early migrations of the aborigines of the North Island. The next tribe of whom we hear in the South Island were the Waitaha. The genealogies of these people show them to have been descended from one Rakaihaitu, who came to New Zealand in the Uruao Canoe some 43 generations ago (as against 19 to 22 generations of the ordinary

Maori genealogies). Traditions attribute to these people a profound knowledge of *karakia* (incantations) and of the science of navigation. The Waitaha after a long sojourn in the south were practically destroyed as a people by the Ngati-Mamoe, who were also an aboriginal tribe, and the last of the *tangata whenua* who held possession of the south of the North Island and the northern part of the South in the neighbourhood of Cook Strait.

So far as we know from the evidence available, a large Maori population inhabited Otago and Southland; and even in the wild and wet West Coast Sounds, Cook found a few inhabitants. The evidence of the whalers and of the first settlers shows that in the first half of the last century there were settlements more or less permanent along the whole of the coast line, and that in the immediate neighbourhood of the Otago Heads there was a native population of three or four thousand persons. Various causes, such as the change in the kind of clothes worn by both sexes, virulent epidemics of smallpox and measles, and change in mode of living rapidly destroyed the population, and now we find only a few scattered families at widely separated intervals.

There are several questions connected with the early inhabitants that can now only be settled by the examination of the sites of villages, which have been abandoned or destroyed and then covered by the drifting sand. The question of most general interest is, perhaps, did the Maori and the moa exist together, or had the moa disappeared as a living bird before there were any inhabitants in this part of New Zealand.

From Shag Point to Preservation Inlet, in every bay and inlet, traces can be found of middens or refuse heaps, and the disturbance and destruction of the vegetation on the inner lines of sandhills by cattle and by human traffic has resulted in the removal of sand which has covered ancient sites for hundreds of years, and of which no tradition remains among the natives who have lived in the neighbourhood for generations.

In other places, such as those at Tautuku and Catlin's River, the age of the deposits is certainly great by reason of the size of the forest trees which have grown over the heaps of shells and bones disclosed by the erosion of rivers, or by man in the process of clearing the land. These middens and village sites along the coast have afforded a very large quantity of implements and relics of stone and bone, and from these can be deduced a good deal of information as to the daily life of the natives. Along certain well-defined tracks to certain districts in the interior may also be found relics indicating more or less permanent settlements in the neighbourhood of tribal hunting grounds.

Much has been written on the question of the moa, but the evidence of the very old middens at Shag Point indicates unmistakably that, at the time when the earliest settlement took place there, a large part of the food supply of the inhabitants of that kainga was derived from moas, of the genus *Pachyornis*. In support of this statement I may state that Mr. F. R. Chapman (now Judge Chapman) and myself made some excavations at this settlement some years ago, in the course of which we found in one small heap

between 50 and 60 necks of these moas, in most cases with the skull attached. The only other bones found were some of the tibiæ, and these were all broken. The position and composition of the midden was such as to preclude any other conclusion than that the heads and necks had been thrown on the rubbish heap as useless for food purposes.

We may therefore conclude that the early inhabitants were moa hunters, and assisted in the disappearance of one of the most remarkable of the forms of bird life. In every midden yet explored traces of the extensive use of bones of the moa for fish-hooks, pins, etc., can be found, but none of these would prove that the natives had hunted the bird.

From the middens we also find evidence that the **tuatara lizard** (Sphenodon), now extinct on the main land, was not uncommon, and at several places, such as Warrington and Long Beach, bones of the extinct notornis and an extinct swan are not uncommon.

Another question is as to the early use of **greenstone**. It was formerly stated that greenstone was not known to the earliest inhabitants. It is certainly very much more scarce in the older settlements, but at Shag Point a worked piece of greenstone was found in the very lowest layers, and I see no reason to doubt that the use of such a hard and beautiful stone was soon recognised by the experts of the Maori stone age.

Large collections of stone adzes, fish-hooks, flints, and ornaments of all kinds have been made by collectors on the sites of old villages which formerly existed on the sandhills in the bays near Dunedin.

One of the most famous localities was a very small bay called Murdering Beach. This seems to have been a dwelling place of chiefs rich in greenstone ornaments, as large numbers of beautiful specimens have been dug up there. Another place which has yielded fine specimens is Papanui Inlet, on the Peninsula. The islands in Foveaux Strait have at one time had a large population, and no doubt a large number of interesting relics will some day be found, and will help us to realise more vividly the genius, industry, and perseverance of the finest race of savages of the Southern Hemisphere.

The more peaceful habits of the southern Maori did not necessitate the construction of the great fortified *pas* with ditches and banks, seen on almost every hill top in the North Island, but tradition states that there were fighting *pas* at Puketeraki, Purakanui, the Heads, and in a few other places.

The south is, however, not without its traditions of war, and at Tuturau, near Mataura, was fought the last great battle which took place in this part. In 1836, at the time of the raids of Rauparaha on the Kaiapoi people, one of his fighting chiefs, Te Puoho, crossed the Haast Pass, and entered Otago by the head of Lake Wanaka with a considerable band of men. They captured or killed the whole of the Wanaka natives, and would have served those of Hawea the same way, but a lad escaped and got away to Hawea, when he warned his tribe, all of whom fled down the Waitaki to the coast. An old native, just dead (Rawhiri Te Maire) was one of these fugitives. Te Puoho carried his captives right down through Central Otago, crossing the mountains to

the present site of Kingston and passing down the Mataura Valley to Tuturau, where he was killed by Topi of Ruapuke and his party destroyed.

Then, again, local history is full of the great deeds of Te Wera of Puketeraki and of the Ngai-Tahu chief, Tara-whai, whose bravery was most extraordinary. One incident in the career of Tara-whai is worth mentioning. By treachery his party of men were killed in an ambuscade; the chief, however, was made prisoner after a desperate struggle. As Tara-whai had been a scourge to these Ngati-Mamoe, they were determined to cut him to pieces alive. He was accordingly laid on his back on the ground, and a native began to cut open his breast with a sharp stone. The attention of those holding Tara-whai being directed at that moment to some strangers who were arriving at the *pa*, he, noticing their inattention, sprang to his feet and succeeded in making his escape into the bush. Being much distressed at the loss of his favourite war club made of whalebone, he determined to attempt its recovery, and accordingly took advantage of the shades of evening to approach the camp of the Ngati-Mamoe. Arriving near the place, he noticed a number of natives seated near the fire. Drawing near, he saw them examining his lost weapon, and talking of the bravery of its owner. Noticing the absence of a Ngati-Mamoe who had a defect in his speech, he walked up to the outer circle and seated himself on the ground, asked (feigning the voice of the man of defective speech) to be allowed to look at the celebrated weapon. It was handed to him by the unsuspecting Ngati-Mamoe, when, jumping suddenly

up, he struck the two nearest to him on the head with the weapon, exclaiming, "The brave Tara-whai has recovered his weapon," which so astonished his enemies that, before they had recovered from their surprise, he had disappeared into the darkness. After several other adventures, he safely regained the shelter of his own fortified *pa*.

Of local names which commemorate incidents and persons of a by-gone day there are many, and it would appear that almost every physical feature, mountain, river, headland, bay, or rock was known to the Maori by its proper name.

As an example, let us take the group of septarian boulders washed out of the greensand cliffs near Moeraki, and widely known by photographers and sketchers as Moeraki Boulders.

According to Maori ideas and tradition this was the scene of the loss of the Arai-te-uru, wrecked here on a voyage to the south in search of the precious stone of Te Wai Pounamu. The reef which extends seaward near the Shag Point represents the petrified hull of Arai-te-uru. After braving the perils of the great ocean of Kiwa and the stormy waters of Raukawa, or Cook Strait, she here lies on her side with the empty hollow of her hull facing towards the mainland, while close to her, in the shape of a prominent rock, stands the petrified body of her commander. Strewed along the beach are some of these huge boulders representing Hinaki or eel-basket of Hape-ki-taurake and the slave Puketapu. The more globular septarian boulders are the calabashes which held the supply of water for those in the canoe, and a number of strangely-shaped irregular concretions further along the shore are the kumaras

The Calabashes of Puketapu, from the wreck of the Arai-te-uru.

(sweet potatoes washed ashore from the wreck, Evidently some of the crew reached land safely, for the surrounding hills bear their names. Towards the south lie two twin hills, Nga tamariki a Hekura (the children of Hekura) and Puketapu, who, whilst gathering firewood, were overtaken and surprised by the dawn, and turned into hills. To the north of these stands Pakihiwitahi (the one shouldered), with his face to the south and his single arm extended, waiting in vain for the return of Puketapu and the children of Hekura.

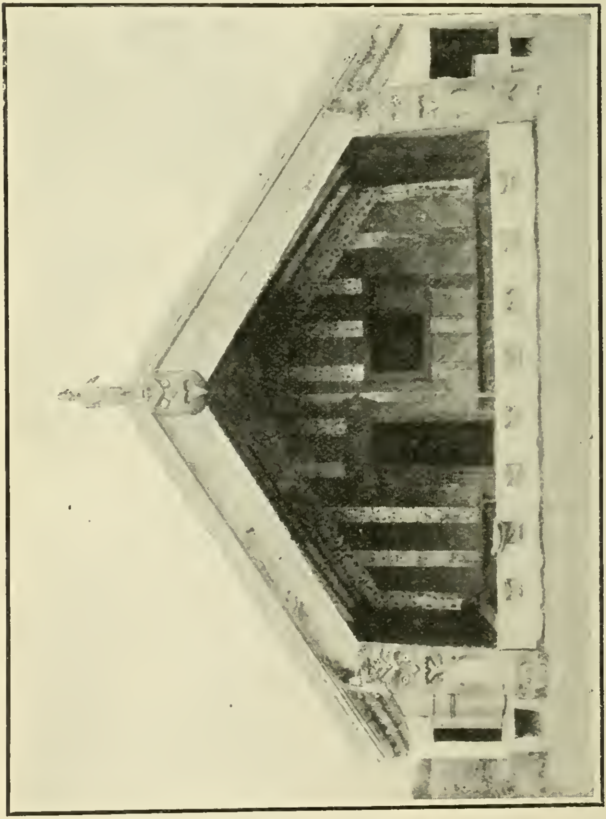
A story of the present century tells of the destruction of the chief settlement near the Otago Heads. About 1817 the piece of flat land on the Peninsula, about a mile from the Heads, was covered with a large and populous Maori village of about 600 houses. There were

also thriving settlements at Kaikai Beach (Takeretawhai), Murdering Beach, and Long Beach (Wharauwerawera). Whale fishing was then at its best, and numerous vessels from Van Diemen's Land and Australia sailed these southern seas, and called occasionally at what is now the Otago Harbour (then known as Port Daniel) or Waikouaiti, and other anchorages on the coast. A vessel named the *Sophia* cast anchor one day just inside the Heads, and a boat put off with seven men and went to Murdering Beach (Whareakeake) to interview a chief residing there, and to purchase some potatoes, which were even then grown by the natives in some parts. During the interview one of the sailors was recognised by a native as the man who had stolen a dried head from some Maoris near Riverton some years previously (1811),* and revenge was naturally sought without delay. After a hard fight four of the crew managed to regain the ship. They found about 150 natives on board, who soon heard of the disturbance and became excited and threatening in their behaviour, and at last, under direction of their chief, tried to take the crew prisoners. However, the large sealing knives carried by the whalers slew so many of the natives that a great number jumped overboard and were drowned in the swift current. The Maori chief was at last overpowered and bound. The account says: "We then threw over 16 bodies that were killed by the knives; the number who jumped overboard and were drowned must have been about 50, and as many were wounded in the

* This was the first dried head offered for sale in Sydney. The account of this massacre is to be found in several old newspapers published in Tasmania and New Zealand, and has been given in detail in the *Transactions N.Z. Inst.*, vol. 28, p. 141

fight." Only two of the crew were wounded. The article then goes on to say:—

"We kept a good watch during the night in case



A Maori House for meetings and for a sleeping house for the people of the place.

of being attacked by a large number of canoes that were drawn up on the beach in front of the town.

"The next morning about 6 o'clock a large number of natives were gathered round the canoes. We

expected that they were going to make an attack on the brig, and that they thought that their chief was killed: they cried out often for him to come on shore. We tied his hands and let him come on deck. When they saw him, there was great rejoicing. He called to them to bring a large canoe-load of potatoes alongside, to pay us, as we thought, for his liberation. A canoe was launched off the beach, with two men to paddle her off to the brig. On the canoe nearing the vessel, one of the men that was stationed aft called out 'The canoe is full of men!' We all rushed aft, and saw the canoe had a large number of men lying in her bottom covered over with mats. Our firearms being already loaded, lying on the deck, we lifted them and fired a volley into her. The natives, who were all armed with short spears and clubs, jumped over the sides of the canoe, and tried to pull it alongside the brig. Had they succeeded, they must have boarded and taken the vessel in spite of all we could do. There were nearly 40 of them and only 14 in all of our crew. Several of them were shot and run through with boarding-pikes in trying to get up the sides of the vessel. Corockar jumped overboard to get to the canoe, but was shot in the neck. Two of his men swam to him and took him on shore in a most gallant manner, but he died next morning of his wounds. Thus we had another narrow escape of being taken and murdered. We kept a good watch all night, expecting to be boarded and taken at daylight.

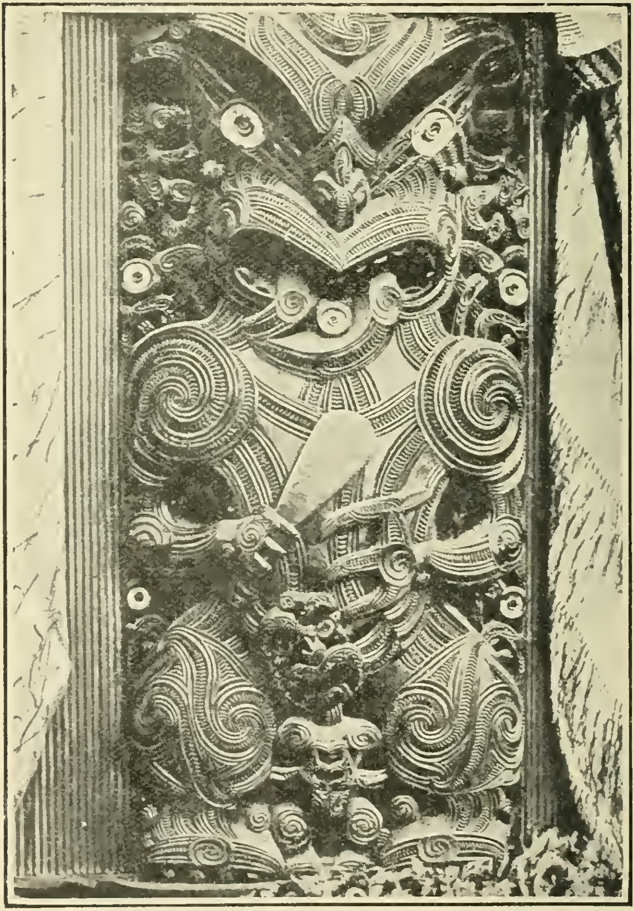
"Next morning, being the 24th of December, 1817, a great number of natives were on the beach making a great noise, seemingly lamenting and crying because of the death of their chief Corockar. They

were preparing to launch their canoes. We thought they were coming off to try and take the brig, and thought it better to stop them if possible. We immediately manned our two boats, and, taking arms and ammunition, pulled close to the beach where the canoes were lying. It was thought most expedient to destroy all their navy at once, to prevent them from making the attempt. As soon as the boats came near the beach, the natives all ran away over the bank. We landed one boat's crew, and kept the other boat afloat to cover the men on the beach with their muskets. We then commenced with two long cross-cut saws cutting the canoes up, each into three pieces. They were 42 in number, large and small, all of which we destroyed, and, as we wanted firewood, we split them up and took them on board. As soon as they saw all the canoes destroyed, they rushed with clubs and spears up to their necks into the water trying to get hold of the boats, but they did not succeed in wounding any of our men.

"They having become more excited and inflexible at this attempt to seize our boats, we determined at once to land, set fire to the town, and burn it to the ground. This was the 26th of December, 1817. It was a fine, clear summer day, blowing a fresh, hot wind from the north-west. We landed nine men, but kept the boats afloat. On our approach the natives all ran to the rising hills, and left us in full possession of the town. This town consisted of about 600 fine houses, and perhaps a finer town never was seen in any part of New Zealand. The fire was lighted at the weather end, and in about four hours the beautiful City of Otago, as we then called it, was laid in a heap of ashes. We now required fresh water for

our sea stock. There were several fresh-water holes on the beach where the canoes were lying. We observed the water in those holes of a curious colour, and recollected that Tucker (the man who was killed by the natives for the theft of the dried head) had told us the natives were in the habit of poisoning the water if they expected their enemies were coming to invade them. On this information we declined taking or using any of the water. On the 27th of December, 1817, at daylight, we weighed our anchor and left Port Otago and sailed for Chatham Islands. Hundreds of natives came down on the shore to see us off. We fired a volley of musketry towards them to say good-bye."

It must not be thought that, either in the North or in the South Island, there was a continual state of warfare, and it is quite a mistake to suppose that the old Maori life in peaceful times was one of privation and suffering; on the contrary, it was a very pleasant state of existence; there was a variety and abundance of food and agreeable and healthy occupation for mind and body. Each season of the year and each part of the day had its specially allotted work both for men and women. The women, besides such household duties as cooking and cleaning their houses, made the cloths and bedding required for their families. They gathered the flax and other fibres used, prepared and worked them up into a great variety of garments, many of which were of a kind that took months to complete, and, when finished, were very beautiful specimens of workmanship. The men gathered the food and stored it in *whata* or storehouses built on tall posts to protect the contents



Carved slab--poupou—from the Maori House in the Colonial Museum, Wellington, representing an ancestor.

from damp and rats. Besides such natural products of the soil as fern-root and other roots, they cultivated in the northern parts *kumara*, *taro*, *hue*, and *karaka*. Fish of various kinds were caught in the proper season and cured by drying in the sun. Wild pigeons, *kaka*, paradise ducks, and *titi* (mutton birds) were cooked and preserved in their own fat in vessels made from the kelp seaweed, bound round with *totara* bark to strengthen them. Netting, carving, grinding by friction, and fitting stone implements and weapons occupied the time of the old men and also much of the young men's time. They beguiled the winter evenings by reciting tales, myths, histories, traditions, and tribal genealogies, chanting and singing poetry, telling fairy tales, and performing dances. It was only when they became ill, and when harassed by their enemies that the ancient Maori can with any truth be said to have been miserable or unhappy. They delighted in war, so that the danger and fatigue on such occasions were more a delight than sorrow or weariness.

Another view of the Moeraki Boulders.

APPENDICES.

I. NEW ZEALAND TOWNS.

AUCKLAND PROVINCE.

Name.	Census, 1911 Population.	Situation.	Industries.
Auckland	102,676 (with suburbs)	Waitemata Harbour	Port. Distributing and commercial centre. Shipbuilding, timber conversion, sugar refining, potteries, etc.
Warkworth	360	Mahurangi Harbour	Agricultural centre, lime and cement works.
Whangarei	2,664	Whangarei Harbour	Port. Agriculture, fruit-growing, cement works.
Kawakawa	161	Bay of Islands	Kauri gum export.
Helensville	616	Kaipara Harbour	Timber.
Dargaville	1,291	Wairoa River	Timber.
Huntly	850	Waikato River	Coal
Ngaruawahia	175	Waikato River	Dairying
Hamilton	3,542	Waikato River	Agriculture, dairying, Phormium fibre.
Thames	3,592	Firth of Thames	Port. Mining and ironworks.
Coromandel	567	Coromandel Harbour	Mining
Waihi	6,436	Ohinemuri River	Mining
Tauranga	1,346	Tauranga Harbour	Agriculture and distributing centre.
Opotiki	683	Waioeka River	Agricultural and pastoral centre.
Cambridge	1,463	Waikato River	Dairying, agriculture.
Te Aroha	1,298	Thames River	Dairying. Tourist resort.
Rotorua	3,544	Lake Rotorua	Tourist resort
Gisborne	8,196	Poverty Bay	Port. Agriculture and pastoral
Onehunga	4,651	Manukau Harbour	Port. Commercial centre.
Paeroa	993	Ohinemuri River	Mining.
Te Kuiti	1,266	... ...	Pastoral
Taumarunui	1,128	Wanganui River	Pastoral, timber.

HAWKE'S BAY PROVINCE.

Name.	Census, 1911 Population.	Situation.	Industries.
Napier	10,537	Hawke Bay	Port. Commercial and distributing centre. Exports, especially frozen meat, wool.
Hastings	6,286	... ...	Agriculture, fruit growing.
Dannevirke	3,368	... ...	Pastoral centre. Timber, dairying.
Woodville	1165	Manawatu River	Pastoral centre. Timber, dairying.
Waipawa	1,083	Waipawa River	Dairying. Pastoral centre.
Wairoa	1,097	... ...	Pastoral

TARANAKI PROVINCE.

New Plymouth	5,238	North Taranaki Bight	Port. Commercial and distributing centre.
Hawera	2,685	S. of Mt. Egmont	Dairying. Pastoral centre.
Stratford	2,639	E. of Mt. Egmont	Dairying.
Inglewood	1,273	E. of Mt. Egmont	Dairying, bacon trade.
Waitara	1,542	North Taranaki Bight	Port. Timber and frozen meat exports.
Patea	919	Patea River	Port. Dairying and pastoral centre. Exports.
Opunake	406	South Taranaki Bight	Pastoral centre.

WELLINGTON PROVINCE.

Wellington	70,729 (with suburbs)	Port Nicholson	Port. Commercial and distributing centre. Manufactures. Seat of Government.
Petone	6,640	Port Nicholson	Wool factory, frozen meat.
Hutt	4,240	Port Nicholson	Pastoral centre
Otaki	658	Cook Strait	Pastoral.
Levin	1,608	Levin River...	Pastoral and dairying

Name.	Census 1911 Population.	Situation.	Industries.
Foxton	1,637	Mouth of Manawatu R.	Port. Phormium fibre, agriculture.
Palmerston N.	10,991	Manawatu River	Agricultural and pastoral centre, commercial centre.
Fielding	3,161	10 m. N. of Palmerston	Agricultural and pastoral centre.
Marton	1,438	25 m. S. of Wanganui	Agricultural and pastoral centre.
Wanganui	10,929	Wanganui River	Port. Commercial centre. agricultural and pastoral centre. Exports.
Hunterville	645	Rangitikei River	Pastoral centre, Timber.
Greytown	1,042	Wairarapa Plain	Pastoral, dairying.
Carterton	1,547	Wairarapa Plain	Pastoral, dairying.
Masterton	5,182	Wairarapa Plain	Agricultural centre. Dairying.
Pahiatua	1,358	"Forty Mile Bush"	Timber, dairying.

NELSON PROVINCE.

Nelson	8,051	Tasman Bay	Port. Commercial centre: fruit, agricultural and pastoral centre.
Richmond	703	Waimea River	Agriculture, fruit.
Motueka	1,229	Tasman Bay	Fruit growing, agri culture.
Westport	4,729	Buller River	Port. Coal mining.
Reefton	1,679	Inangahua River	Gold mining
Denniston	831	... ...	Coal mining.

MARLBOROUGH PROVINCE.

Blenheim	3,771	Wairau Plains	Pastoral and commercial centre.
Picton	1,361	Queen Charlotte Sd.	Port. Frozen meat.
Kaikoura	385	Kaikoura Peninsula	Pastoral centre.

CANTERBURY PROVINCE.

Name.	Census 1911 Population.	Situation.	Industries.
Christchurch	78,442	Avon River	Commercial and distributing centre. Various small factories.
Lyttelton	40,58	Banks Peninsula	Port.
Akaroa	622	Banks Peninsula	Port. Pastoral.
Ashburton	2,673	Ashburton River	Agricultural and pastoral centre.
Temuka	1,741	Temuka River	Agricultural and Pastoral centre.
Timaru	11,280	S. Canterbury Bight	Port. Commercial and distributing centre.
Waimate	1,762	Waitaki River	Agricultural and pas. toral.
Belfast	620	Canterbury Plains	Frozen meat.
Fairlie	597	Opihi River	Pastoral centre.
Kaiapoi	1,823	Canterbury Plains	Woollens.
Rangiora	1,834	Canterbury Plains	Agricultural and pas. toral centre.
Geraldine	945	Canterbury Plains	Pastoral centre.

WESTLAND PROVINCE.

Greymouth	5,469	Grey River	Port. Coal, gold, and timber export.
Brunner	1,008	Grey River	Coal mining.
Hokitika	2,291	Hokitika River	Timber and gold.
Kumara	783	Teremakau River	Gold mining
Ross	643	Mt. Greenland	Gold mining.

OTAGO PROVINCE.

Dunedin	64,237 (with suburbs)	Otago Harbour	Port. Commercial and distributing centre. Various small factories.
Oamaru	5,152	East Coast	Port. Agricultural and pastoral centre.
Palmerston S.	792	Shag River	Pastoral centre.
Port Chalmers	2,100	Otago Harbour	Port.
Green Island	1,872	Kaikorai River	Coal mining

Name.	Census 1911 Population.	Situation	Industries.
Mosgiel	1,496	Taieri Plain	Woollen mill. Agricultural centre.
Milton	1,347	Tokomairiro Plain	Agricultural and pastoral centre.
Kaitangata	1,567	Clutha River	Coal mining.
Lawrence	911	Clutha River	Gold mining. Pastoral centre.
Balclutha	1,261	Clutha River	Agricultural and pastoral centre.
Cromwell	587	Clutha River	Gold mining.
Alexandra	772	Clutha River	Gold mining.
Queenstown	696	Lake Wakatipu	Gold centre. Tourist traffic.
Gore	3,258	Mataura River	Gold. Agricultural and pastoral centre.
Mataura	1,198	Mataura River	Paper mills. Meat freezing.
Invercargill	12,782	Oreti River	Commercial and distributing centre. Small factories.
Campbelltown	1,780	Bluff Harbour	Port.
Riverton	936	Aparima River	Timber.

NOTE.—There are meat freezing works, tanneries, and many small factories at or near all the large centres. The total of the former is 34, of the latter 119.

II. GEOLOGICAL FORMATION.

Arranged according to their relative age.

ERA I. AZOIC—*No life existed during this era.*

System.	Corresponding N.Z. Division.	Distribution in New Zealand.
1. Archean	Manapouri System	Granite Gneisses, etc., of West Coast fiords. Otago Schists ?

ERA II. PALAEOZOIC—*Fish, shell-fish, and non-flowering plants the dominant form of life.*

1. Cambrian	?	
2. Ordovician	Takaka System	Marbles, syenites, and slates in western Nelson. Otago Schists ?

System.	Corresponding N. Z. Division	Distribution in New Zealand
3. Silurian 4. Devonian	Baton River System	Limestones and shales near Reefton.
5. Carboniferous	Maitai System	Slates and sandstones. Main portion of Southern Alps and of North Island axis Coal of Europe and America.
6. Permian	Kaihiku System	Sandstones. Hills near Clinton and Upper Rangitata R.

The Carboniferous and Permian cannot, in the opinion of the author, be distinguished from the Triassic and Jurassic rocks.

ERA III. MESOZOIC—*Reptiles, and dominant animals. Gymnosperms, (Pines and Cycads) the dominant plants*

1. Triassic 2. Jurassic	Hokonui System	Sandstones and greywackes. Some of eastern ranges of Southern Alps, Hokonui Hills, Forest Range, Kawhia and Waikato Heads.
3. Cretaceous	Waipara System	Sandstones and marls. East of Wellington Province, North Canterbury. Coal seams of Greymouth and Westport.

Recent researches show that the Cretaceous rocks of New Zealand are in reality merely the lowest division of the Cainozoic era to which they are completely conformable

ERA IV. CAINOZOIC—*Mammals the dominant animal. The same types of plants as at present.*

NOTE.—The Geological Survey has placed the Oamaru System and part of the Waipara between Cretaceous and Cainozoic times as Cretaceo-Tertiary.

1. Eocene	?	
2. Oligocene	Oamaru System	Marine limestones and coal measures generally in coastal districts.

System.	Corresponding N.Z. Division	Distribution in New Zealand.
3. Miocene	Pareora System	Marls and clays. Upper Wanganui and Hawke's Bay. South Canterbury.
4. Pliocene	Wanganui System	Sandstones at Wanganui, gravels at Nelson and Canterbury Plains.
ERA V. ANTHROPOZOIC—*Man the dominant animal*		
		Gravels and sands round sea margin. The ice age of Europe and America. Great extension of New Zealand glaciers.

III. PRINCIPAL MOUNTAINS IN THE MORE IMPORTANT RANGES.

NORTH ISLAND.

	Height in feet.	
Ruapehu	9,175	Volcanoes.
Egmont	8,250	
Ngauruhoe	7,515	
Tongariro	6,458	
Makorako	5,700	Kaimanawa Mountains.
Hikurangi	5,606	Raukumara „
Hector	5,016	Tararua „
Manuaha	4,603	Huiarau „
Parks Peak	4,466	Ruahine „

SOUTH ISLAND.

Snowdon	5,800	Tasman Mountains.
Arthur	5,800	„ „
Domett	5,300	Marine „
Franklyn	5,671	Spenser „
Travers	5,666	„ „
Tapuaenuka	9,467	Landward Kaikouras.
St. Bernard	7,416	

	Height in feet.	
Kaitaru	8,700	Seaward Kaikouras.
Whakari	8,500	
Enys	7,202	Eastern ranges of chain of Southern Alps.
Torlesse	6,554	
Hutt	7,180	
Arrowsmith	9,171	Northern part of Southern Alps.
Tyndall	9,279	
Edison	7,903	

Southern Alps. Mt. Cook Region.

	Height in feet.		Height in feet.
Mount Cook	12,349	La Perouse	10,090
Tasman	11,467	De la Bêche	10,040
Malte Brun	10,421	Haast	9,835
Sefton	10,390	Darwin	9,715
Elie de Beaumont	10,176	Green	9,325
Haidinger	10,107	Hochstetter	9.258

Southern Alps. South Portion.

Aspiring	9,975	
Castor	8,286	
Pollux	8,341	
Earnslaw	9,165	Barrier Mountains
Edward	8,459	,, ,,
Cosmos	7,340	,, ,,
Ansted	8,157	,, ,,
Tutoko	9,042	Darran Mountains
Christina	8,675	,, ,,
Larkins	7,432	Richardson Mountains
Double Cone	7,638	Remarkables ,,
Bonpland	8,102	Humboldt Mountains.
Anau	6,294	Western Ranges.
Albert Edward	5,103	
Mary Peaks	5,500	
Brunel	5,559	Takitimu Mountains.
Ida	5,552	Hawkdun ,,
Kakanui Peak	5.019	Kakanui ,,
Herbert	3,142	Banks Peninsula.
Anglem	3,200	Stewart Island.

IV. PRINCIPAL NEW ZEALAND RIVERS.

The length given does not include distance round narrow curves and bends.

North Island.

Western Side.

	Length.		Length.
Wairoa	95 miles to Kaipara Heads	Waitotora	54 miles.
Waikato	215 miles including Lake Taupo	Wanganui	153 ,,
		Wangaehu	82 ,,
		Turakina	59 ,,
Mokau	63 miles.	Rangitikei	124 ,,
Waitara	52 ,,	Manawatu	120 ,,
Patea	67 ,,		

Flowing South.

Ruamahanga 67 miles.

Eastern Side.

Pahaoa	41 miles.	Waiapu	62 miles.
Tukituki	71 ,,	Motu	55 ,,
Ngaruroro	85 ,,	Whakatane	65 ,,
Mohaka	75 ,,	Rangitaiki	95 ,,
Wairoa	63 ,,	Thames	93 ,,
Waipoa	50 ,,	Piako	62 ,,

South Island.

Flowing North.			
Motueka	62 miles.	*Eastern Side.*	
		Clutha Including Lake Wakatipu	197 miles.
Western Side.			
Grey	75 ,,		
Buller	92 ,,	Taieri	116 ,,
Haast	53 ,,	Waitaki Including Lake Pukaki	143 ,,
Hollyford	46 ,,		
Flowing South.		Rangitata	74 ,,
Waiau measured through Lakes Te Anau and Manapouri	94 ,,	Rakaia	85 ,,
		Waimakariri	90 ,,
		Hurunui	85 ,,
		Waiauua	100 ,,
Aparima	65 ,,	Clarence	120 ,,
Oreti	95 ,,	Awatere	75 ,,
Mataura	104 ,,	Wairau	108 ,,

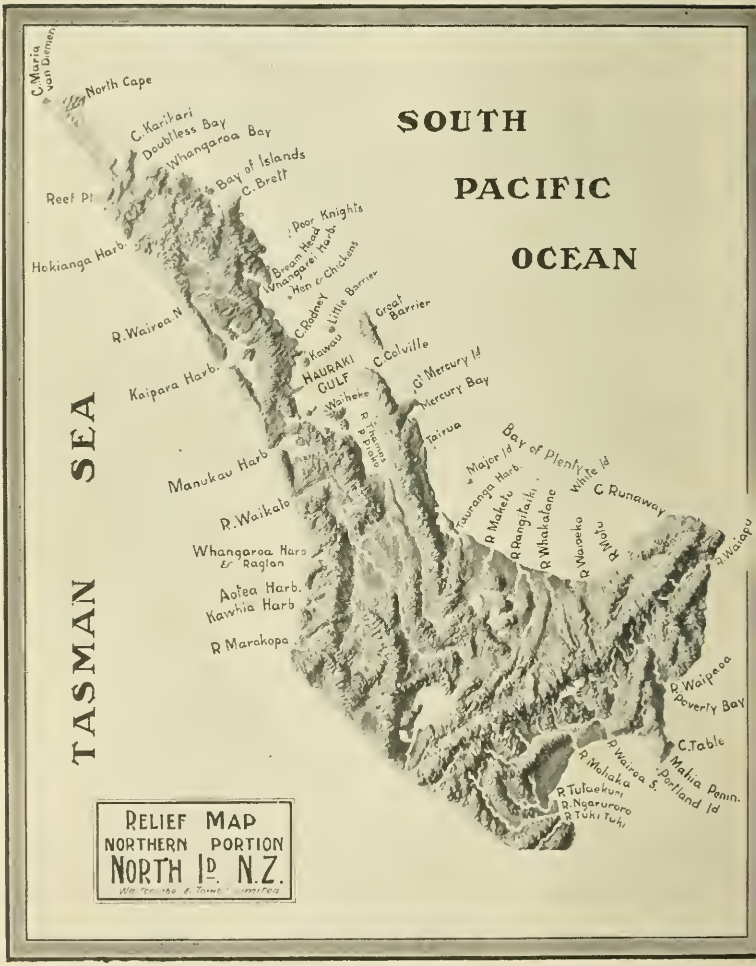
V. PRINCIPAL NEW ZEALAND LAKES.

NORTH ISLAND.

Name.	Province	Area in square miles	Height of surface above sea level.	Depth in feet.
Taupo	Auckland	238	1211	534
Rotorua	,,	32	915	84
Wairarapa	Wellington	27	—	—
Waikaremoana	Auckland	31	2015	846
Tarawera	,,	15	1040	—
Rotoiti	,,	14	915	230
Waikare	,,	11	65	9
Rotoaira	,,	5	1506	—
Rotomahana	,,	3	1240	600

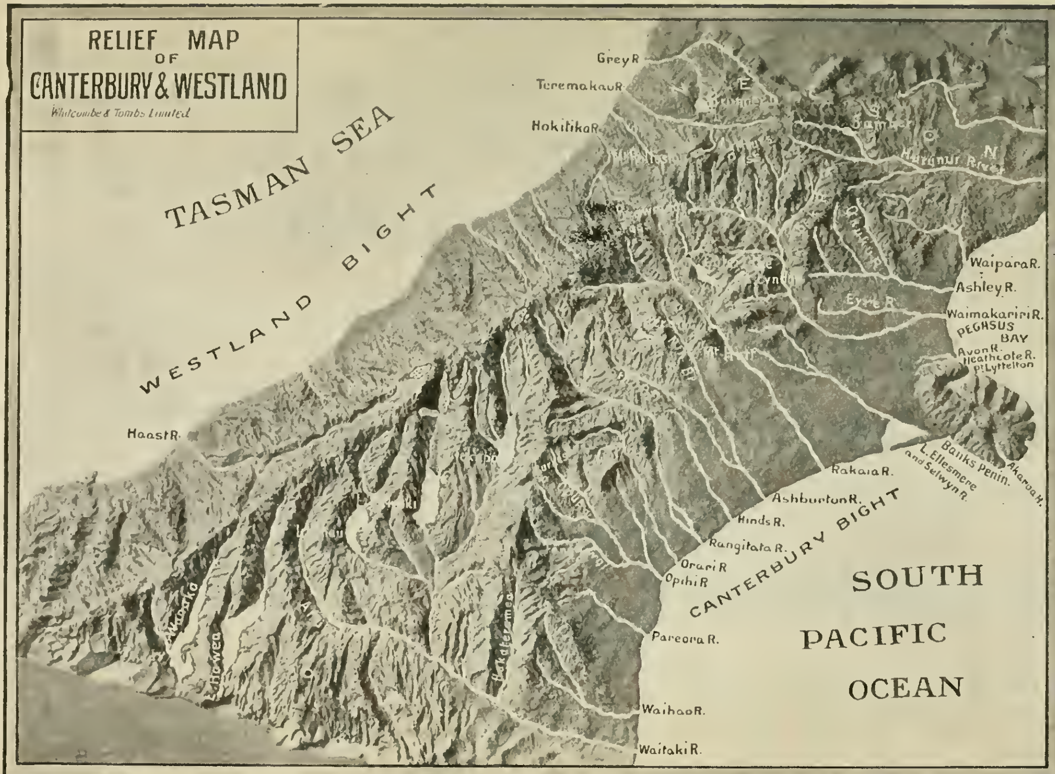
SOUTH ISLAND.

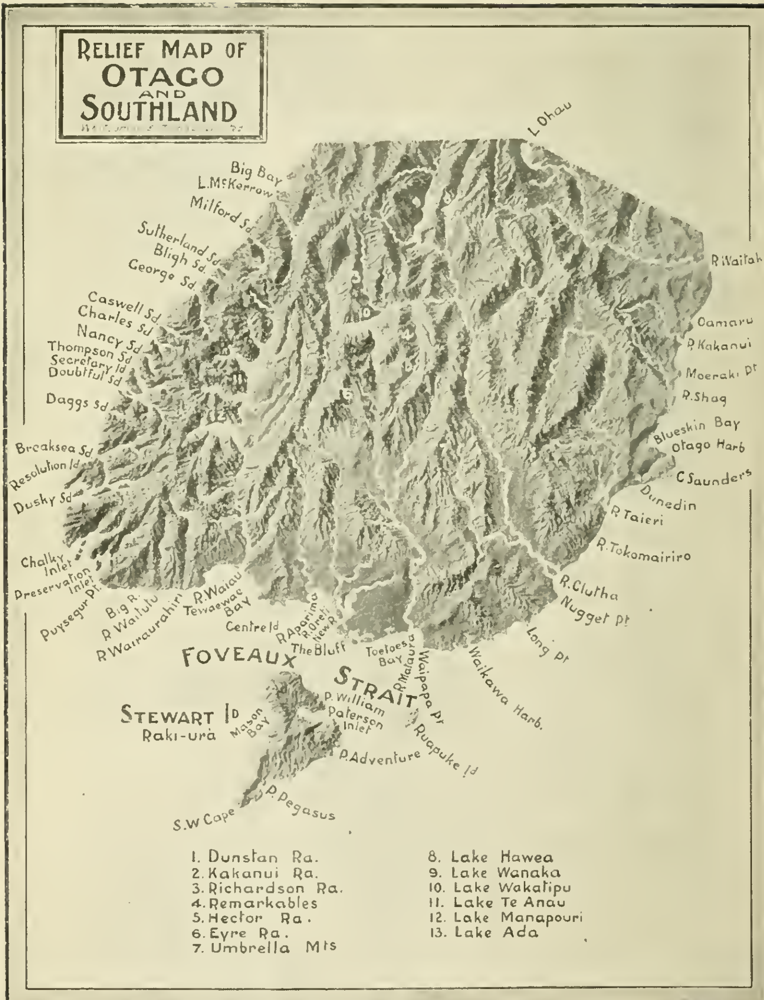
Name.	Province	Area in square miles	Height of surface above sea level.	Depth in feet.
Te Anau	Otago	132	694	—
Wakatipu	,,	112	1016	1239
Wanaka	,,	75	920	—
Manapouri	,,	56	597	1458
Hawea	,,	48	1062	—
Tekapo	Canterbury	32	2321	—
Pukaki	,,	31	1588	—
Hauroto	Otago	25	611	—
Ohau	Canterbury	23	1720	—
Coleridge	,,	18	1667	—
Poteriteri	Otago	17	96	—
Brunner	Westland	15	281	—
Monowai	Otago	12	600	—
Rotorua	Nelson	8	2700	—
Kanieri	Westland	8	422	646
Waihola	Otago	7	—	—
Sumner	Canterbury	5	1720	—


RELIEF MAP
NORTHERN PORTION
NORTH Id. N.Z.
SOUTH
PACIFIC
OCEAN
TASMAN SEA
C. Maria van Diemen
North Cape
C. Karikari
Doubtless Bay
Whangaroa Bay
Bay of Islands
C. Brett
Reef Pt
Hokianga Harb.
Poor Knights
Bream Head
Whangarei Harb.
Hen & Chickens
Little Barrier
Great Barrier
C. Rodney
Kawau
R. Wairoa N.
Kaipara Harb.
HAURAKI GULF
C. Colville
Gt Mercury Id
Mercury Bay
Waiheke
R. Thames
R. Piako
Tairua
Manukau Harb
R. Waikato
Whangaroa Harb & Raglan
Aotea Harb.
Kawhia Harb
R Marakopa
Bay of Plenty
Major Id
Tauranga Harb.
White Id
C Runaway
R Maketu
R Rangitaiki
R Whakatane
R Waioeko
R Motu
R. Waiapu
R. Waipaoa
Poverty Bay
C. Table
Mahia Penin.
Portland Id
R Wairoa S.
R Mohaka
R. Tutaekuri
R. Ngaruroro
R Tuki Tuki


RELIEF MAP
SOUTHERN PORTION
NORTH I^D. N.Z.
SEA
TASMAN
R Mokau
North Taranaki Bight
R.Waitara
C.Egmont
South Taranaki Bight
R Waingongoro
R.Patea
R.Waitotara
R Kai-iwi
R.Wanganui
R.Wangachu
R.Turakina
R.Rangitikei
R.Manawatu
Kaimanawa Mts
Ruahine Mts
Hawke Bay
R.Tutaekuri
R.Ngaruroro
R.Tukituki
C.Kidnappers
R.Porangahau
C.Turnagain
Kapiti I^d
R.Aohanga
Castle Point
SOUTH
PACIFIC OCEAN
Cook Strait
C.Terawhiti
Port Nicholson
R Hutt
C.Turakirae
R.Ruamahanga
Palliser Bay
R.Pahaoa
C Palliser


RELIEF MAP OF NORTHERN PORTION OF SOUTH Id. N.Z.
C. Farewell
Golden Bay
R. Aorere
Collingwood
R. Takaka
D'Urville Id
COOK STRAIT
Tasman Bay
French Pass
Pelorus Sound
R. Motueka
R. Wai-iti
Nelson
R Karamea
Karamea Bight
Westport
R. Buller
C. Foulwind
Q. Charlotte Sound
Port Underwood
R. Wairau
R Awatere
C Campbell
R Clarence
R Grey
Greymouth
Kaikoura
Kaikoura Penin.
R Conway
R Waiau
Port Robinson
1 Kaikoura Ra.
2 Seaward Kaikouras
3. St Arnaud Ra
4 Spencer Mts
5 Brunner Ra.
6 Paparoa Ra.
7. Lyell Ra.
8. Lake Brunner
9 Lake Hochstetter
10 Lake Ahaura
11. Lake Haupiri
12 Lake Cristabel
13 Lake Rotoroa
14 Lake Rotoiti
SOUTH PACIFIC OCEAN


RELIEF MAP
OF
CANTERBURY & WESTLAND
Whitcombe & Tombs Limited
TASMAN SEA
WESTLAND BIGHT
Grey R.
Teremakau R.
Hokitika R.
Haast R.
Hurunui River
Waipara R.
Ashley R.
Eyre R.
Waimakariri R.
PEGASUS BAY
Avon R.
Heathcote R.
Pt. Lyttelton
Banks Penin.
Akaroa H.
L. Ellesmere and Selwyn R.
Rakaia R.
Ashburton R.
Hinds R.
Rangitata R.
Orari R.
Opihi R.
CANTERBURY BIGHT
Pareora R.
Waihao R.
Waitaki R.
SOUTH PACIFIC OCEAN
Hawea
Pukaki


RELIEF MAP OF
OTAGO
AND
SOUTHLAND
L. Ohau
Big Bay
L. McKerrow
Milford Sd.
Sutherland Sd.
Bligh Sd.
George Sd.
Caswell Sd.
Charles Sd.
Nancy Sd.
Thompson Sd.
Secretary Id.
Doubtful Sd.
Daggs Sd.
Breaksea Sd.
Resolution Id.
Dusky Sd.
Chalky Inlet
Preservation Inlet
Puysegur Pt.
Big R.
R. Waitutu
R. Wairaurahiri
R. Waiau
Tewaewae Bay
Centre Id.
R. Aparima
R. Oreti
New R.
The Bluff
FOVEAUX
STRAIT
Toetoes Bay
R. Mataura
Waipapa Pt.
Waikawa Harb.
Long Pt.
Nugget Pt.
R. Clutha
R. Tokomairiro
R. Taieri
Dunedin
C. Saunders
Otago Harb.
Blueskin Bay
R. Shag
Moeraki Pt.
R. Kakanui
Oamaru
R. Waitaki
STEWART Id.
Raki-ura
Mason Bay
P. William
Paterson Inlet
P. Adventure
Ruapuke Id.
P. Pegasus
S.W. Cape
1. Dunstan Ra.
2. Kakanui Ra.
3. Richardson Ra.
4. Remarkables
5. Hector Ra.
6. Eyre Ra.
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8. Lake Hawea
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